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ABSTRACT

The different uses of computers in education were surveyed. Three major uses were defined: as a laboratory tool, as an instructional management tool, and as a teaching instrument. As a laboratory tool the computer is used as electronic equipment, a calculator, an automaton, a simulator, and a research and development tool. Instructional management uses are divided into information banks, testing aids (answer processing, test generation, and individualized testing), and computer-managed instruction. As a teaching instrument the computer can be used for drill and practice, tutorial work, or dialog. In each use classification, the application is presented, examples are given, instructional and technical aspects discussed, and experiments cited. Volume 1 gives the classification scheme that forms the foundation for volumes 2 and 3. (WH)

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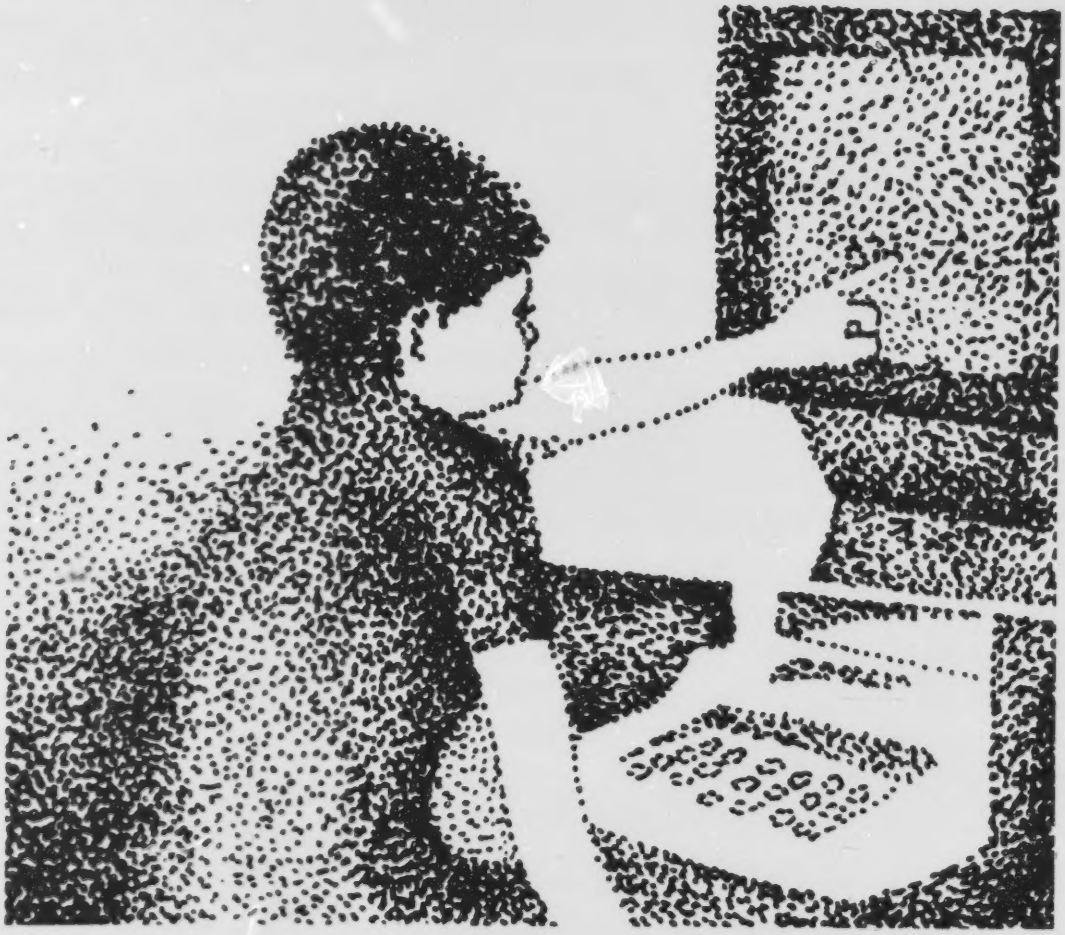
Report on The Instructional Use of the Computer

Volume I
Types of Uses



Service de l'Informatique
Ministère de l'Education
Province de Québec
Canada

IR 000 644

ED 092086

The instructional use of the computer

Volume I

TYPES OF USES

Report on

THE INSTRUCTIONAL USE OF THE COMPUTER

Volume I

Types of uses

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Laboratoire de Pédagogie Informatique
Service de l'Informatique
Ministère de l'Éducation du Québec
March 1973

The three volumes* of the document "The Instructional Use of the Computer" are the result of a report submitted to the Department of Education in March 1973 by the Laboratoire de Pédagogie Informatique. This study, directed by Mr. William Lee, continues the work done by the Laboratory set up in 1968 within the Department of Education's Data Processing Service.

In the first volume the classification and description of the types of instructional uses to which the computer may be put are the work of Guy Chevalier and the experiment reports, the work of Bernard Gateau.

The second volume on the costs of the various computer uses was written by François Labrousse.

The third volume which describes the scope of computer use in education is the work of Lucien Dubé.

The final copy was put together and given its finishing touches with the assistance of Miss Diane Laflamme and Mrs. Céline Brochu.

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*Volume 1: "Types of uses"
Volume 2: "Costs"
Volume 3: "Scope"

INTRODUCTION

The purpose of this report is to make the present instructional uses of the computer known and to make recommendations to the Quebec Department of Education concerning the policy to adopt in this field.

The functions of the Laboratoire de Pédagogie Informatique included informing the Department of the possibilities of computer-assisted instruction and suggesting ways in which such instruction could be developed in this province.

This is the objective of the volumes which follow. The first three attempt to describe the role played by data processing in education today; the last analyzes this role on the basis of the present orientation of our educational system and makes recommendations for preparing for and organizing the instructional use of computers in Quebec.

As mentioned at the beginning of each volume, the report was written by several different persons in the laboratory. Its coherence derives from the use in all the volumes of the classification introduced in the first.

This report endeavors to deal with the principal problems arising from the instructional use of computers although it does not

pretend to do so exhaustively. The recommendations mainly concern the pre-university level.

The possible importance of educational technology in Québec and particularly the new lease on life the computer can offer education was present in the authors' minds throughout their work. It was their objective to transmit this awareness to their readers.

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CHAPTER I

INTRODUCTION

1.1 Why have a classification?

Classifying the *instructional uses of the computer* seemed an effective method of studying the field. The goals were:

- to acquire a well-defined terminology by removing certain ambiguities encountered in the American and French data-processing vocabularies. It will be noted that we chose terms, which, while remaining descriptive of the type of use, sometimes diverge from the terms generally employed (or from their translation).
- to describe all the present applications for each category presented.
- to forge a tool to be used when discussing the cost, effectiveness and scope of the various applications.

1.2. Present terminology

One of the most striking aspects of research and development in the instructional use of the computer is the diversity in the vocabulary and the scarcity of definitions.

Alan B. Salisbury lists over twenty terms used by the Americans to denote CAI*type applications (58)**.

Several authors, each according to his particular interests, have listed or classified terms associated with the various ways of using computers in education. The lists drawn up by Helen A. Lekan (42), Entelek (22), Robert A. Seltzer (61), J.H. King (38) and Alan B. Salisbury (58, p.38) are given in figures 1, 2, 3, 4 and 5 respectively.

Salisbury's classification is particularly interesting and exhaustive. It includes all computer uses in the school from automatic payroll systems to fully computerized instruction, including the setting up of timetables, curricula, tests and so on. Its main interest is in the implied relations between the various types of applications.

Such a classification could not be applied in this report since our sole object was to study the instructional uses of the computer.

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*Computer-assisted instruction

**The figures between parenthesis in the different volumes all refer to references found at the end of each text.

Adaptive

Computer Assisted Instruction

Diagnostic

Dialogue

Drill and practice

Evaluation

Gaming

Information Retrieval

Inquiry

Interview

Intrinsic

Investigation

Learner-controlled

Linear

Problem solving

Simulation

Tutorial

etc...

Fig. 1 *Helen Lekan's list of program logics* (42)

LPI Report, 1973, vol. 1

1.2...

- Tutorial
  - . Linear
  - . Intrinsic
  - . Adaptive
- Problem Solving
- Socratic
- Laboratory (simulation)
- Game

Fig. 2 *Entelek's classification of types of CAI courses (22)*

Drill and practice

Tutorial

Simulation (gaming)

Information Retrieval

Computational Display Device

Aid to Artist

Dialogue

Fig. 3 *Robert Seltzer's classification of computer uses (61).*

1.2...

Computational Aid

Simulation

Lesson material storage and retrieval

Lesson prescription

Testing

Interactive Instruction

Fig. 4 *J.H. King's classification* (38, p.87)

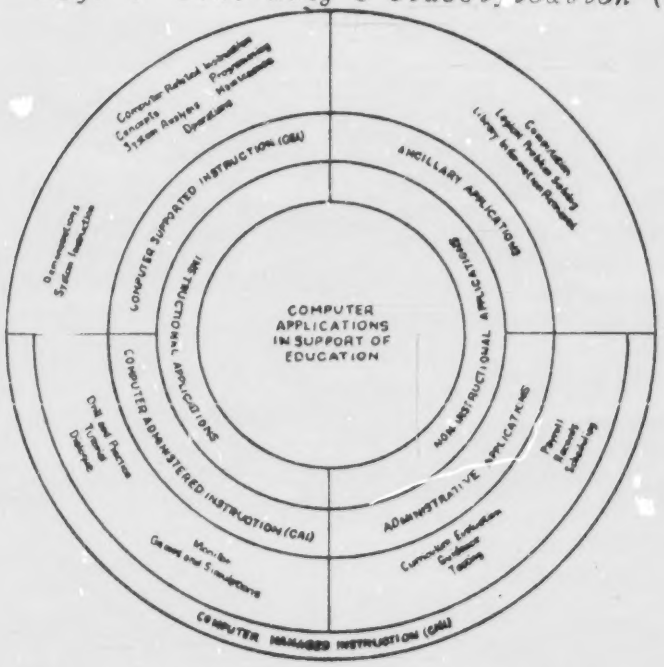

Fig. 5 *Alan B. Salisbury's illustration of types of computer applications in support of education. (58, p. 38)*

1.2...

Generally speaking, terms used to describe experiments or instructional systems are poorly defined if defined at all. The term CAI has been given widely differing meanings as illustrated in the two excerpts below:

> "The term 'Computer-assisted instruction' is used at OISE* in a very broad sense to designate *any use of the computer in an interactive role of student diagnosis or instruction.*" (50, p.3)

> "CAI is the most significant of the instructional applications, and as used in this article is defined as: A man-machine interaction in which the teaching function is accomplished by a computer system without intervention by a human instructor. Both learning material and instructional logic are stored in computer memory." (59, p.48)

This confusion does not facilitate study in this area of computer applications. Added to this is the difficulty in translation. In the educational field as well as in data-processing, French and English words do not always have exact equivalents. Terms such as "instruction" or "management" for instance often undergo slight changes of meaning when translated.

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* Ontario Institute for Studies in Education

1.3 Suggested classification

This classification has the following characteristics:

(a) it describes instructional applications only (as opposed to administrative applications);

(b) in our opinion, it takes all the known applications into account;

(c) it is based on the instructional functions of the various applications rather than the hardware (equipment) or software (data-processing systems) used;

(d) there is a certain progression, from the simple to the complex, wherein the applications of the upper categories (within the classification) have the characteristics of the applications in the preceding categories.

It should be noted that the classification used in the present text is translated from its original French version. The French classification appears on page 9 and should be referred to if the meaning of the translation doesn't seem clear.

1.3...

There are three major categories of applications in the classification of the instructional uses of computers (see fig. 6b, page 10 which is the version of the French classification shown in fig. 6a, page 9).

(i) The computer as a LABORATORY TOOL. The role of the computer in this case is not to transmit information (teaching) but to be directly available to the users (students, teachers and so on) as a tool with which they may experiment. The expression "Computational Aid" is sometimes used.

(ii) The computer as an INSTRUCTIONAL MANAGEMENT TOOL. In this case, the computer participates in instructional management with its memory and calculating abilities (testing, distribution of instructional resources and so forth) but does not actually teach. The expression "Computer Management" is often used.

(iii) The computer as a TEACHING INSTRUMENT. In this case, the computer is the teaching medium in the same way as a written text, a teacher or a film. Because of its particular characteristics, the computer can be a medium for man-machine interaction and the program (course) can be adapted to the needs of the user.

In our opinion, these three major fields of application overlap. When used as a *teaching instrument*, the computer is

also participating in instructional management (it controls students performance, their progress in a course, the information presented to them and so forth). Similarly, a computer used for *instructional management* and a computer used as a *laboratory tool* presuppose the same possibilities as regards hardware and software (equipment and program).

INSTRUMENT DE LABORATOIRE

- Appareil électronique
- Calculateur
- Automate
- Simulateur
- Instrument de recherche pédagogique

INSTRUMENT DE GESTION PEDAGOGIQUE

- Banques d'information
- Evaluation
  - . Analyse et traitement de réponses
  - . Génération et correction de questionnaires
  - . Evaluation individualisée
- Gestion de cheminement

INSTRUMENT D'ENSEIGNEMENT

- Exercices répétés
- Enseignement de type tutoriel
- Enseignement de type non-directif

Fig. 6a) Original version of the classification.

LABORATORY TOOL

- Electronic equipment
- Calculator
- Automaton
- Simulator
- Research and development tool

INSTRUCTIONAL MANAGEMENT TOOL

- Information bank
- Testing aid
  - . Answer processing
  - . Test generation
  - . Individualized testing
- Instructional management aid

TEACHING INSTRUMENT

- Drill and practice
- Tutorial
- Dialogue

Fig. 6b) Classification of instructional uses of the computer

LPI Report, 1973, vol. I

1.4 Content of Part I

The purpose of the first part of this report is to present the various instructional uses to which the computer is put today. Using the above classification, we will endeavor to give a formal description and examples of each particular type, and bring out the main technical and instructional characteristics of the various applications.

With a few exceptions, we have endeavored to respect the following plan for each sub-category in the classification:

(a) Presentation of the application

This presentation usually boils down to a definition of the application under study and a list of equivalent terms used to identify the same application.

(b) Examples

The examples given are intended to illustrate both the definition and the explanations of the instructional and technical aspects. The examples were not meant to be exhaustive or to present the most important experiments. Simplicity and representative character were the only criteria used.

(c) Instructional aspects

In this section the application in question will be presented with regard to the services rendered to the student or teacher. These services may be in terms of the problems to be solved, whether in learning, motivation or student adaptation to environment, or again in terms of the possibilities offered for transmitting and processing information.

(d) Technical aspects

The technical aspects developed may be of three different types depending on the applications:

- hardware and software required for the application (type of processing, type of data processing system and so on).
- the instructional limitations of the application.
- the degree of facility with which students and teachers have access to the application.

(e) Experiments

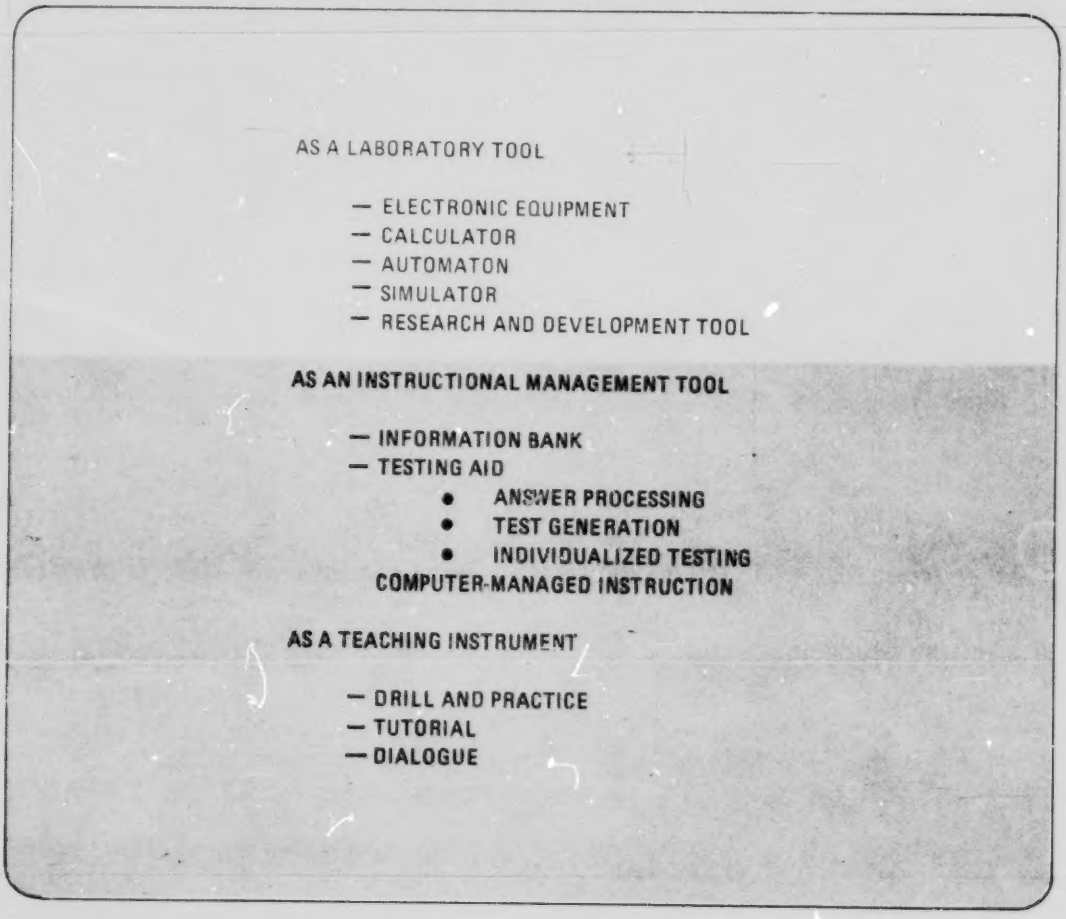
This section describes experiments conducted to measure the applications' effectiveness as regards a student's performance, his learning time, or his general attitude towards the various systems. It will be noted that the various applications in this report were not all researched to the same extent. There are fourteen reports on *tutorial instruction* but none on *electronic equipment* or *dialogue*.

This is due to various factors, among which the following are the most important:

- Certain types of use are more recent than others or became widespread at a later date.
- The very nature of some types of use makes experimentation difficult. The experiments undertaken result in simple, completely unscientific appreciations even though they may indicate the degree of interest in the field.
- Many experiments on the instructional use of the computer are efforts to introduce a particular system. The results of such *experiments* lead to an assessment of the introduction rather than an assessment of the effects of the system introduced. The reports on these *experiments*, then, are actually descriptions of the system, its advantages and its theoretical possibilities.

Our study was based on reports of experiments published between 1968 and 1972. Our main sources were the magazine *Educational Technology*, the *ENTELEK* cards and the *ERIC* microfiches. The experiments in this report were chosen for their quantitative results.

CLASSIFICATION OF THE INSTRUCTIONAL USES OF THE COMPUTER



CHAPTER 2

THE COMPUTER AS
A LABORATORY TOOL

2.0 Introduction

One of the characteristics of contemporary education is undoubtedly the emphasis placed on pupil participation in the learning process. Depending on the method proposed, the pupil either handles concrete material or has direct contact with the phenomena studied. The objective is active research. The pupil is requested to *discover* rather than assimilate. Greater emphasis is placed on the learning process and the development of intellectual mechanisms which can be transferred to other types of learning, than on the content to be learned.

The increasingly important place of the computer in most fields of human activity, the amazing technological developments in this field and the impact of the new data-processing techniques on work organization and life in general make contact with data-processing necessary for an ever greater portion of the population.

For this reason, the purpose of many of the computer applications in schools is to put the pupil and the teaching personnel in direct contact with the computer. In this type of application, the

2.0...

computer's role is not to transmit specific information. The computer is a powerful machine made available to individuals for use in accordance with their own needs. The systems developed within this framework are simply meant to make a single computer available to several local or remote users.

Where instruction is concerned, the computer does work which the student has himself defined and programmed or carries out more or less complex calculations in very short periods of time. Programs in which the computer simulates experimental situations can help the student grasp certain phenomena being studied.

In this chapter, five major types of computer applications as a *laboratory tool* will be studied, namely, the use of the computer as:

- *electronic equipment*
- *a calculator*
- *an automaton*
- *a simulator*
- *a research and development tool*

Particular attention will be given to the *calculator*, the *automaton* and the *simulator*.

2.0...

Because we want this study to be as complete as possible we should mention that, in fact, the use of the computer as an *electronic equipment* is very special and will be treated rather briefly. The use of the computer as a *research and development tool*, on the other hand, is a special application for which the usual presentation plan will not be respected.

It should be noted that the applications of the computer as a *laboratory tool* have not been the subject of advanced systematic research, at least not as regards the instructional aspects of these applications.* Most of them do not readily lend themselves to scientific research. It is impossible, for example, in this field of application, to compare the use of the computer to other techniques since the computer has an original role which no other machine and no person can play.

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* As opposed to technical research on equipment and software.

2.1 *Electronic equipment*

2.1.1 Presentation

In this case, out-dated computers or electromechanical instruments are used to teach electrotechniques, electronics, basic computer concepts and so on.

2.1.2 Examples

IBM made a second generation computer, the 1401, available to the electronics department of the Trois-Rivières CEGEP on condition not to use it for commercial purposes. The department uses it in its course on computer electronics to familiarize the students with computer circuitry. The students can modify the computer, add functions or remove them. Such computers are low-priced since they have been outdated on the modern market.

There are also a certain number of small instruments on today's market created especially for teaching concepts of data processing: decision elements, Boolean algebra, sequential control of instructions, memory and so on.

2.1.3 Characteristics

This is not the place for a long description of this type of computer use. Quite simply, this application has the following instructional and technical characteristics:

- it enables students to handle the equipment without danger of damaging a complex and expensive system;
- it makes a trial and error learning process possible;
- it replaces long theoretical lectures on the parts and functions of a computer.

The student learns from contact with a real,relatively inexpensive machine on which he can experiment.

2.2 *Calculator*

2.2.1 Presentation

In this case, the computer is used as a desk calculator. It has an advantage over ordinary desk calculator in that it can carry out stored programs and extremely complex calculations.

2.2.2 Examples

(i) At the University of Calgary, the students in education have a series of programs at their disposal which, given data (hypothetical or real student results and so forth), make the required statistical calculations and print the results in tables or graphs. (32).

(ii) TRAJET, a program set up by Mr. Félix Deforest of the Université du Québec in Trois-Rivières plays the same role in the solution of problems in mechanics. Using the proposed data, it makes very complex calculations in a matter of seconds and gives the student results he can interpret. (13).

(iii) In August 1971, SIMEQ made the ITF system available to certain CEGEP. It is a conversational system in which the computer can serve either as a *calculator* or as an *automaton*.

2.2...

During the first year, at least 30% of the programs offered used the computer as a *calculator*. Specifically, at the Shawinigan CEGEP, Mr. André Bélanger developed a series of programs enabling his students to solve complex calculations. The *TAB* program for example, "makes a conversion table for changing the percentage of transmutance into absorbance and the *BOR* program "calculates the radii, speeds and energies of electrons in given orbitals."*

2.2.3 Instructional aspects

Computer calculation is on the fringe of instructional applications. Some authors actually refuse to consider any instructional purpose to this type of use. It cannot be ignored, however, for it is one of the most widespread uses which is rapidly adopted whenever a data processing system is available in a teaching establishment. Obviously, this type of use is found almost exclusively in the sciences. Its main advantages in instruction are the following:

- it permits students to come into contact with a computer without being discouraged by the need to learn the language;
- it allows students to concentrate on the phenomena being studied rather than the calculations required;
- it eliminates laborious calculations which often draw the students' attention away from the real problem.

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* The information on these programs was obtained from the description of available ITF programs.

2.2.4. Technical aspects

The attraction of the computer as a *calculator* is understandable in view of the ease with which it may be used both by the teacher and the students. Its simplicity is evident in two ways:

- The teacher can rapidly program the computer for this type of application even for complex calculations. Once written, the program can be used by a large number of students.

- When an interactive system is used, the student is guided by the computer which "asks" him what kind of calculation he wants to make, what data must be processed and, often how the results are to be displayed. This is done in a "conversation" and does not require any special coding by the student.

The problem of coding is sometimes greater when using batch processing although most authors of such calculation programs try to minimize it. In general, the student is given a set of punched cards for each program. To obtain the necessary calculation, he simply chooses the required set, adds his card with the data and hands the entire lot over to the operators.

Until now, most of these calculation programs were batch processed. Because of their power and their growing availability, interactive systems are being used increasingly for this type of application when the volume of data is

not too great. There are two advantages: less coding and immediate results.

2.2.5 Experiment results

To our knowledge, no systematic experiment has been made in an effort to show the instructional utility of computer calculation.

At the Shawinigan CEGEP*, 62% of the 40 students using the computer for their chemistry problems expressed satisfaction in a questionnaire.

As regards time gained, it is obvious that a few minutes with a computer or a terminal are sufficient to replace several hours with logarithmic tables and slide rules. Moreover, with a computer, students can try several values when analyzing a phenomenon and study the consequences as seen in the different results.

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* See report no. 1, paragraph 2.7.

2.3 *Automaton*

2.3.1 Presentation

The computer is said to be used as an automaton when programming is the actual end sought either when learning computer languages or when endeavoring to develop intellectual skills which can be transferred to other fields of student activity.

In this type of use, programming means learning. *To program* means to express in a language the machine can understand a series of actions which must be performed in order to solve a problem.

The computer may be used as an *automaton* in order to attain two different goals which are not necessarily mutually exclusive:

- teaching data-processing and particularly computer languages.
- acquiring intellectual skills: mathematical logic, algorithmic thought processes, investigation and problem solving techniques and so on.

2.3.2 Instructional aspects

i) Teaching data-processing

The use of the computer as a *laboratory tool* was introduced very naturally into the teaching of computer languages.

"Practice makes perfect". At SIMEQ, over 1,000 CEGEP student programs are processed each day, not counting the programs which can be written in the conversational languages of the ITF system.

In several scientific and technological disciplines an ability to program and a knowledge of computers have become necessary because of the services computers can render. Practice seems to be the most effective way of learning to program. Very few formal studies have been carried out to verify this assumption but it has become customary to use the computer as an *automaton*. Teaching data-processing however, is only one special case in this type of computer use.

ii) Acquiring intellectual skills.

For a few years now, several researchers and education experts have been recommending programming and the teaching of a computer language as methods of developing certain intellectual skills. This line of thought concurs with modern research in didactics and the pedagogical theories with which names such as Dewey, Decroly, Claparède and Montessori are associated.

Pedagogically speaking, the main characteristic of the computer used as an *automaton* is the complete initiative left to the student when he is working in direct contact with a computer.

2.3.3 Examples

i) At the Sherbrooke CEGEP, Mrs. Marie-Jane Haguel (30) experimented with the use of APL by the students. The students learned APL with an accompanying document and programming exercises. Once introduced to the language, they had to draw up projects and write the corresponding programs. The projects (chosen, defined and executed by the students themselves) dealt with pollution, income tax reports, poetry composition and so forth. The results of aptitude tests on logic and the initiative shown by the students in the course seemed satisfying enough to justify continuing the experiment.

ii) Since 1967, the MIT (Massachusetts Institute of Technology) Artificicial Intelligence Laboratory has been working on the development of a conversational system which would facilitate the use of the computer as an *automaton* and on a research project in the didactics of mathematics. The first experiments were done on the elementary level but applications on the secondary and college levels were also attempted. The language used is LOGO which was especially developed for this type of use. The student first learns the language which, incidentally, is very simple, through trial and error, writing out short programs to guide the progress of a vehicle (called "turtle"). The instructions are of the type FORWARD, BACKWARD. With these instructions,

the student can write out very complex programs. He then either defines a project himself or is assigned a project. In either case he is obliged to use the given elements of a problem to analyse it, define the variables and express the algorithms required for its solution. He must then programme these algorithms in LOGO, have his program carried out in order to discover errors and reformulate or redefine his solutions until the program solves the given problem. LOGO does more of course than simply guide the "turtle". It has the usual possibilities of a conversational language (51-45).

iii) An important experiment in the use of the computer as an *automaton* is the one the Montreal Catholic School Commission (MCSC) has been working on for two years now. In 1972, over three hundred secondary school students were able to become acquainted with a computer during an experimental mathematics course. The CAMP* experiment was developed by a group of mathematics teachers at the University of Minnesota High School in Minneapolis (39). The aim of the experiment is to "teach students in the junior and senior high schools how to utilize the computer in the solution of mathematical problems and the development of mathematical ideas." (39, introduction).

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* Computer Assisted Mathematics Program

2.3.3...

The mathematics teacher participating in the experiment includes an introduction to "BASIC" in his course. BASIC is a conversational language meant as a tool for teaching sciences. The student uses it to write out, have executed and correct short programs. He can thus better assimilate what he learns in mathematics.

After a course on the absolute value of numbers, for instance, the following exercises are given the student:

"5- Give the absolute value of: 5, -3, 182, 0, -56, -31

6- Write a program to print the absolute value of 5, -3, 182, 0, -56 and -31.

7- Run the program that you wrote for exercise 6 on the computer. Does the output agree with your answers for exercise 5? If not, find your error and correct it." (39, paragraph 7.8)

2.3.4 Technical aspects

In the *automaton* mode the computer can be used either in batch processing or conversational. When teaching programming languages to future programmers, batch processing is generally used.*

For intellectual training, however, the use of the computer as an *automaton* is generally done through a conversational system. This is only natural in view of the importance of immediate feedback in such an application and the "dialogue" characteristics of the conversational systems.

In the *automaton* application the preparation of instructional material is reduced to a minimum. No programming is required by the instructor. The system is bought, or supplied with the computer and the student does his own programming. The instructional environment for such an application may be compared to that required of a physics, chemistry or, better yet, language laboratory. Equipment must be available and projects on which the students are to work must be defined.

2.3.5. Comparison with the *calculator*

There are many similarities between the *calculator* application and the *automaton* application since the student

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* At present, in view of the fact that the computer, used to teach programming, always falls into this category, batch processing is used most of the time.

who uses the computer in the *automaton* mode will often write out calculation programs. Moreover, these programs are often kept in stock and can later be used in computer calculation by the same students or their colleagues.

As a rule, the uses can be distinguished by the objectives sought:

- if the aim is to do a calculation in which the result is more important than the procedure, the computer is being used as a *calculator*;
- if the aim is to do a calculation in which the procedure required to obtain the result is more important than the result itself, the computer is being used as an *automaton*.

2.3.6 Experiment results

The only experiments on the use of the computer as an *automaton* encountered during our readings give qualitative appreciations of its instructional effectiveness. At the Shawinigan CEGEP*, for example, all the students (100%) expressed satisfaction with the computer used as an *automaton* in their chemistry course. At the Sherbrooke CEGEP**, the experiment seems to point to an increase in the students'

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* Report no. 1, paragraph 2.7

** Example i), paragraph 2.3.3

2.3.6...

initiative and sense of responsibility in the subjects taught.

At the Université Laval, the experiment is now a fact. The APL system is available to students about twenty hours a day and the high rate of usage suggests that the system fulfills definite needs.

2.4 *Simulation*

2.4.1. Presentation

In this type of use, the computer reproduces a phenomenon on which the student can experiment actively.

2.4.2. Examples

(i) At the University of Illinois (Project PLATO) biology students taking a course in genetics have access to the equivalent of a research laboratory. The computer can generate a drawing of fruit flies on the plasma display panel. The student can choose the flies with which he wants to experiment (interbreed them, discard them and so on). The drawings are extremely precise and the individual specimens illustrated can differ in some fifteen ways (by their sex, the shape of their wings, the size and shape of their eyes and limbs, their color and so on). The student can reconstitute the laws of heredity by interbreeding the flies, observing the characteristics of the descendants and repeating the process as often as desired, either with the same or with different couples.

(46, p.15)

(ii) The Ryerson Systems Institute in Toronto uses three different simulations in an effort to enable industrial management personnel to acquaint themselves with the new management techniques resulting from the introduction of computers into enterprise.

2.4.2 ...

In one of these simulations, *Computer Facility Management Corporation* the students, working in teams, manage a company selling "computer time". They have to set the prices and plan their advertising, and the services the fictitious company will provide. The computer simulates market conditions on the basis of their decisions and provides information on the company's economic situation. (19)

(iii) At Sir George Williams University, Professor D. Mitchell of the Department of Education is setting up a simulation program which will initiate future teachers to the instructional management of a class. The student teacher informs the computer by means of punch cards, of the subject he wishes to teach, the strategy and media he intends to use, the general organization of his class (divided into sub-groups for instance) and so on. The computer provides him with data on the behavior of the class in terms of individual performance, motivation and so forth.

The student teacher can then modify his approach to the subject, his strategy or any other variable for which the computer is programmed and experiment with it (47, 48).

2.4.3 Instructional aspects

From a pedagogical point of view, simulation presents very interesting possibilities. Like in the case of the *automaton* application, it leaves a lot of room for research and personal work in the learning process. The student using simulation does not need to be controlled, since the effect of his decisions

2.4.3 ...

and actions becomes obvious as the simulation progresses.

From another standpoint, in computer simulation a student can experiment with and become familiar with phenomena in a way which would otherwise be impossible. Secondary students, for instance, could not conceivably have atomic reactors or betatrons at their disposal, but this equipment can be simulated be a computer.

2.4.4 Technical aspects

From the technical point of view, the effort required for simulation depends on the nature of the phenomena or equipment simulated and the precision with which they are to be simulated. The Ryerson Institute's three simulations, for example, require between 60 and 180 hours of preparation per average hour of use by a group of students. Preparation includes creating the model and preparing and correcting the program .

Simulations can use almost any type of terminal, from card reader units and printers to the latest cathode screens (or plasma display panels) , including output tables and typewriter terminals.

The processing method (batch or conversational) also varies with the applications, the amount of data, the required or desired response time and so forth.

2.4.4 ...

Here too, however, the use of conversational systems seems to be more and more widespread where the smaller-scale simulations used in secondary or college level instruction are concerned.

2.4.5 Experiment results

Computer simulation can be used in most school subjects, from economic geography and medecine to business management, physics and biology. The results of three experiments on this type of application are found at the end of the chapter. *

In the Montgomery College project, the computer simulation of a physics laboratory (the mechanics of shocks) enables the students to carry out about ten times as many experiments as they could in a traditional physics laboratory. This is in part due to the considerable reduction in equipment required for the experiments.

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* reports 2, 3 and 4 of paragraph 2.7

2.4.5 ...

The use of the computer as a *simulator* generally arouses enthusiasm among the students involved in the experiments. This enthusiasm, however, is not a sure criterion of instructional effectiveness as the results of the experiment at John Hopkins University in Baltimore would seem to indicate. *

Used rationally, the computer can play a very important role as a *simulator*.

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* report no 3, par. 2.7

2.5 *Research and development tool*

2.5.1 Presentation

The computer used as a *research* and *development tool* covers a vast array of applications involving either the development and testing of instructional material or research on teaching and learning theories.

2.5.2 Development of instructional material

In an article on computer applications to education (63), Harry F. Silberman discusses the possibilities of the computer as a research and development tool. He distinguishes the following:

- The statistical analysis of data from experiments with instructional materials (audio-visual aids, programmed instruction, computer instruction and so on).

- The use of CAI to produce didactic material which will not necessarily be distributed by the computer.*

- The syntactic and semantic analysis of texts to be used as instructional material. Using programs which can read

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* By CAI, the author undoubtedly refers to the three types of uses included in our third category, *drill and practice*, *tutorial* and *dialogue*.

2.5.2 ...

natural language, the texts can be analyzed by computer for syntactic error, ambiguities, useless redundancy, inappropriate use of vocabulary prior to its definition and so on.

The author notes, however, that this type of application is still in the research stage.

- The generation of drill items which the authors of individualized courses or even class instructors could use.

- The evaluation and generation of instructional sequences to encourage learning. The computer can be used to present various instructional modules in different sequences, evaluate the performance of various personality types in the different sequences and then generate the optimal sequences for individuals or particular groups of individuals.

All these possibilities are included in the research on the development of techniques for minimizing the time required to prepare instructional material. The problems of delimiting subject matter, chosing strategies and media and so on are found not only in computerized instruction but also in audio-visual instruction, programmed instruction and formal lecture courses. Instructional documents are the result of a cycle involving elaboration, evaluation and revision (cf. fig. 7). This cycle tends to lengthen the preparation time and increase production costs significantly. The various possibilities listed above make it possible to test the material before or during elaboration and thus reduce the number of evaluation-revision cycles necessary for good results.

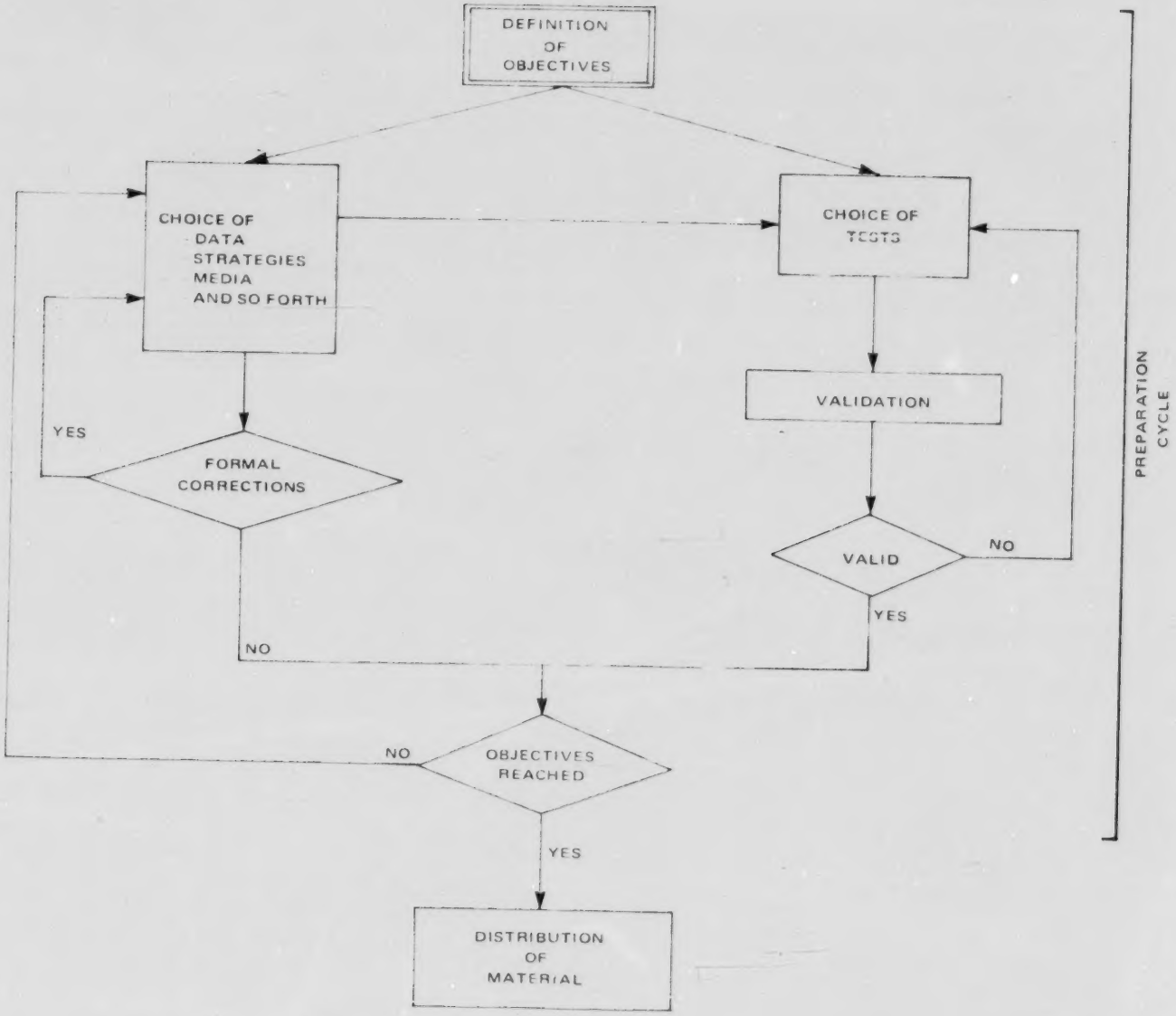

Fig. 7 Illustration of cycle for preparation of instructional material

2.5.3 Example

Mr. Gary M. Boyd of Sir George Williams University in Montréal has developed what he calls a "Laboratory for CAI Lesson Research and Development" (5,6). Basically, this laboratory makes it possible to reduce preparation time for individualized course material (this material will eventually be presented to the student as programmed tests or through a teaching machine). A teacher and a student work simultaneously at two isolated terminals. * They can communicate with each other and are both connected with a computer whose sole function for the moment is to register all messages.
A closed-circuit television system enables the teacher to show the student slides or films. The teacher gives his course using this audio-visual material and his keyboard. He offers explanations, shows pictures, answers the student's questions, asks him questions, comments on the student's answers and so forth.

Using the computer's record of the teacher's and the student's messages, programs separate each other's interventions and produce a copy of the messages. The teacher reviews the text and deletes the useless or over-specialized information.

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* In this case, the terminal is a cathode ray tube and a keyboard.

On the basis of this corrected text, the computer generates a program enabling any other student to take the course without the teacher.

The operation is of course repeated with several people representative of the student body the course is intended to serve. By making the necessary deletions, it is possible to produce a course adapted to most of the students. The computer can then put out the definitive text of the document ready to be used as a programmed course. At Sir George Williams University the computer, using such a text, can even generate a program for adapting the text to a private teaching machine.

2.5.4. Theoretical research in education*

The amount of scientific research done in education has increased noticeably over the past twenty-five years as a result of a new educational technology which had to be tested for effectiveness both from an educational and an economic point of view. At the same time, these new methods provided research

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* The following text is based in part on an analysis by Albert E. Hickey (33).

2.5.4

instruments capable of leading to a better understanding of "the conditions of learning"*. The everwidening use of the computer makes possible and often induces a great deal of research in this field. The following is a schematic listing of (a) the main fields of investigation in education, (b) the way of using a computer for research purposes, (c) the advantages of so using a computer.

(a) Fields of investigation

(i) Research on theories of learning

- model development
- model or theory verification
- application of models to concrete situations
- and so forth

(ii) Research on the factors influencing learning

- the effects of reinforcement and feedback
- the influence of social factors
- individual characteristics
- gathering and analysis of data on existing instructional systems.

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* The expression is from Gagné.

2.5.4 ...

(iii) Research on organization and teaching techniques.

- research on the effectiveness of the various media
- comparison of media
- relation between the learning processes and instructional sequences
- and so forth

(b) Main ways of using a computer for educational research.

(i) *Information banks*

- gathering empirical data
- storing information during long-term experiments
- and so forth

(ii) *Simulator*

Simulation makes it possible to test dynamic models, verify the influence of various factors on the initial hypothetical situation, optimize the processes simulated and so on.

(iii) *Tutorial instruction* is widely used to study the factors which influence learning. This type of use, besides making it possible to keep track of all the man-machine interactions, also makes it possible to reproduce a large number of teaching situations by changing the variables to be studied at will.

(c) Advantages of using the computer in research and development projects.

(i) The computer makes possible the precise and rapid processing of large quantities of data. It can store an almost unlimited quantity of information.

(ii) When using simulations or practicing *tutorial instruction*, a laboratory situation may be created in which the experimenter has increased control over the variables being studied or the variables which might act upon his experiment unduly.

(iii) The computer makes possible the immediate and dynamic use of results at the time of their registration and during later stages of the same experiment or during subsequent experiments.

2.6 *Laboratory tool* - conclusion

In the third volume of this report (Scope), the rapidity with which the use of the computer as a *laboratory tool* has developed will become obvious. The phenomenon, although particulary evident in the United States, is world-wide. This expansion is undoubtedly due to a large degree to technical development in the data-processing and tele-communications fields, but it also reflects a definite desire to bring the student into closer contact with the computer in order to make his learning more dynamic and to expose him to an environment which will be a reality in the near future.

The conversational systems developed especially for teaching (or learning) were designed to facilitate the use of the computer. Pedagogically, this facility of access is doubled by the relative simplicity of installing the elements necessary for the various applications*. The computer used as a *laboratory tool* is an object which in varying degrees, can be used by anyone regardless of his learning theories or the methods he prefers. It can make possible learning experiences which no other equipment permits. This is particularly true

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* This simplicity is *relative* to other types of applications in which the preparation of the instructional material requires a considerable amount of work, as for example when the computer is used as an *instructional management tool* or a *teaching instrument*.

of those activities in which the computer plays the role of an *automaton* or *simulator*.

The almost total lack of controlled, scientific experiments to confirm the sometimes surprisingly optimistic affirmations of the promoters and users of these systems, however, at times makes it impossible to form a true idea of the systems' real instructional value. This is especially regrettable in those areas in which a generalization of the applications could incur considerable expense.

2.7 Experiment reports

REPORT NO. 1

INSTITUTION CONCERNED : Shawinigan CEGEP

USE : *Laboratory tool*

LEVEL : College

SUBJECT : Chemistry

REFERENCE : (3)

COMMENTS :

It took 10 hours to initiate 40 students to the possibilities of the ITF conversational system. There was one terminal available.

RESULTS :

62% of the students expressed satisfaction with the computer used as a *calculator*.

100% expressed satisfaction with the computer used as an *automaton;*

77% expressed satisfaction with the computer used as a *question bank*.

Moreover, 89% of the students want to use ITF again next year.

REPORT NO. 2

INSTITUTION CONCERNED : Los Angeles County General Hospital

USE : *Simulator*

SUBJECT : Medecine: anaesthesiology

REFERENCE : (1)

COMMENTS :

The students had at their disposal a computer-controlled mannikin, "Sim One". Sim One breathes, has heart beats, temporal and carotid pulsations and blood pressure. He reacts to doses given with a mask or a tube.

The aim of the experiment was to see whether five interns practicing on the mannikin (experimental group) would acquire professional competence in "endotracheal intubation" with fewer sessions in the operating room than five other interns (control group). It was also hoped that the experimental group would become competent more rapidly than the control group after their first session in the operating room. The experimental group spent between 5.5 and 9.5 hours with "Sim One".

RESULTS :

On the average the experimental group required 30.0 operating room sessions to meet the criterion "nine out of ten positive results" while the control group required 57.8; the difference is significant ($p < .05$).

There is an approximate possible gain of 75% in time. Moreover, the authors of the experiment believe this method could spare patients a certain amount of pain.

REPORT NO 3

INSTITUTION CONCERNED : John Hopkins University in Baltimore

USE : Simulator

LEVEL : Secondary

SUBJECT : Economic geography

REFERENCE : (44)

COMMENTS :

The experiment involved between 20 and 40 students. The player has to modify certain parameters to give his country the highest possible standard of living.

RESULTS :

There was no significant difference in either motivation or learning for the 22 eighth grade students of low academic ability. The result was the same for 32 eighth grade students of average and above-average ability and for 40 tenth and eleventh grade students.

The students and teachers participating in the simulation, moreover, were enthusiastic.

On the basis of the measure used, the authors conclude that there is not always a relation between enthusiasm and learning or between enthusiasm and motivation to learn.

REPORT NO 4

INSTITUTION CONCERNED : Montgomery College, Maryland

USE : *Simulator*

LEVEL : Secondary

SUBJECT : Physics: mechanics of shocks

REFERENCE : (4)

COMMENTS :

80 students took a four-item pretest. 68 who did not reach the terminal objective were divided into two groups: an experimental group of 29 using the computer and a control group of 39.

After each group had received 55 minutes of class instruction, the experimental group worked with the computer while the control group did the laboratory experiment. The following day, the students took a four-item posttest.

RESULTS :

Pretest:

GROUP	MEAN SCORE	STANDARD DEVIATION
EXPERIMENTAL	1.72	.87
CONTROL	2.31	.88

LPI Report, 1973, vol. I

The control group was significantly superior to the experimental group *before* the practical work.

Posttest:

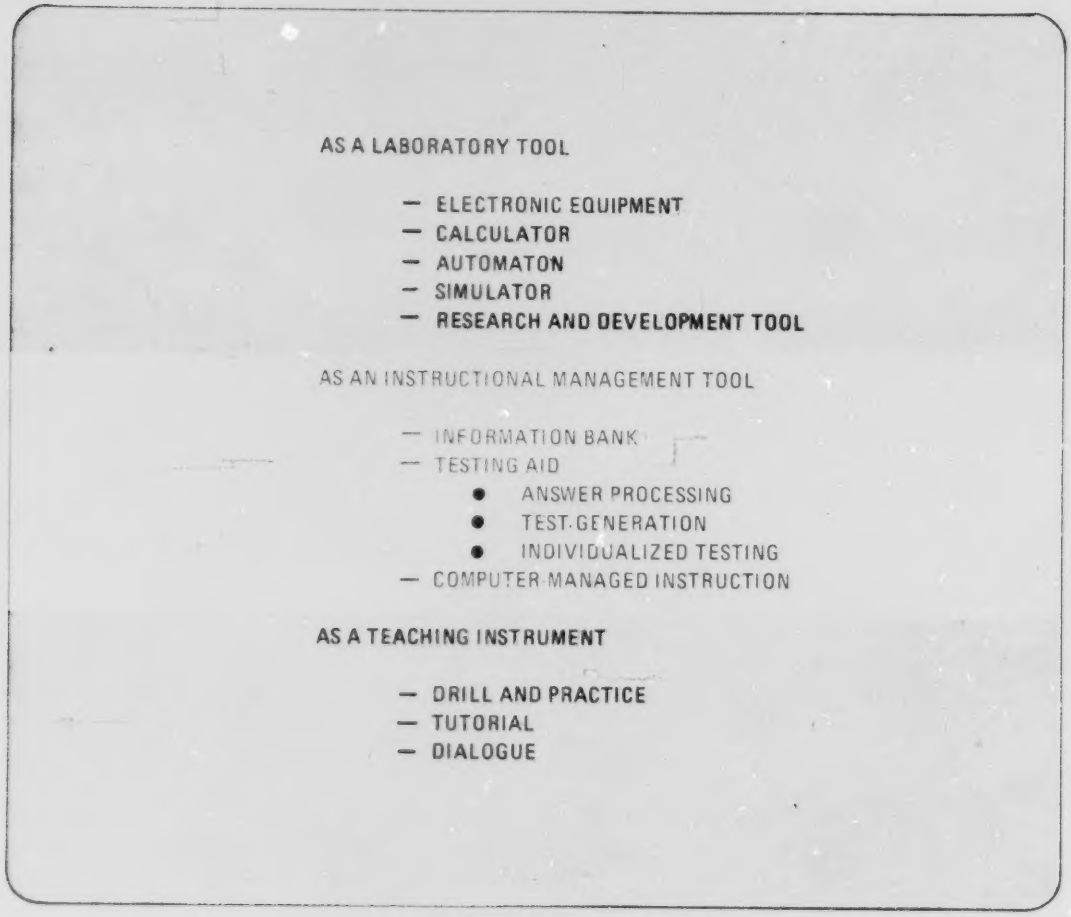
GROUP	MEAN SCORE	STANDARD DEVIATION
EXPERIMENTAL	3.21	.66
CONTROL	2.72	.75

The experimental group was markedly superior to the control group *after* the practical work.

There was a noticeable increase in the average of the experimental group as compared to that of the control group.

GROUP	MEAN GAIN
EXPERIMENTAL	1.48
CONTROL	.41

CLASSIFICATION OF THE INSTRUCTIONAL USES OF THE COMPUTER



CHAPTER 3
THE COMPUTER
AS AN *INSTRUCTIONAL MANAGEMENT TOOL*

3.0 Introduction

3.0.1 Presentation of the context

There is a relatively new trend in education(especially in North America), that of conceiving the solutions to educational problems comprehensively; the various elements (components or functions) of the system (transmission and control of knowledge, performance of the individual and the system, and so forth) are interrelated. The term *system approach* is often used. *

The problems encountered in education are considered to be global. Information needs are considerable from the point of view of the student (the information explosion), and the teacher as well as the administrator whose decisions affect the whole of the educational system. The instructional

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* A good definition of the System Approach in education has been given by the Department of Audio-Visual Instruction Commission (U.S.)

"An integrated programmed complex of instructional media, machinery, and personnel whose components are structured: as a single unit with a schedule of time and sequential phasing. Its purpose is to insure that the components of the organic whole will be available with the proper characteristics at the proper time to contribute to the total system, and in doing to fulfill the goals which have been established"
(21), p. 614

LPI Report, 1973, vol. I

social and economic* implications of these decisions emphasize even further the importance of having access to comprehensive data concerning the state of the whole system at a given moment and the effects of changes introduced into the system. Such general concerns are also found at the level of the individual and his activity within the system when he must make decisions concerning his vocational and academic career, and even in the details of his choice of educational objectives, learning activities, etc.

In such a context, the role of the persons involved in the whole educational system (students, professional and teaching personnel, administrators, and so on) is one of *management* of educational resources. Concerning the role of the teacher, for instance, P. David Mitchell of Sir George Williams University wrote:

> "Recent educational technology research and practice has emphasized not only the institutionalized replacement of some instructional functions of the teacher by other means and modes of instruction but also the changing nature of the teacher's role toward that of manager of the educational process". (47), p.223.

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* In industrialized countries, one third of the budget is devoted to education.

For the past few years, the system approach in education and the notion of instructional management have been a center of growing interest on the part of theoreticians and practicians in education. In 1970, for instance, *Educational Technology* published seven articles with titles containing the word "Management"; in 1971 this figure rose to 22. Since June 1972, this review has had the subtitle, "The Magazine for *Managers* of Change in Education". Today it would be difficult to consult a magazine in the educational field without encountering a suggested model for an instructional management system.

Although the details may vary, these models have a certain number of characteristics in common, in particular:

(a) Any definition of the system proceeds from a strict definition of the *needs* the system endeavors to meet. These *needs* may be expressed in terms of *problems to be solved* or *objectives to be reached*. Needs are defined by analyzing the *present* situation and describing the desired situation. The difference between these two *states* constitutes a definition of the needs or outlines the changes to be brought about.

(b) The system approach requires a definition of steps in the development of the proposed system. Each step consists of operations to be carried out and controls for determining the efficiency of these operations during the development of the system or once it is set up.

(c) *Instructional management* models all provide for numerous mechanisms making it possible at various stages to feed the data provided by assessment back into the system. With feedback the system can be dynamically adapted to the changing conditions of the environment.

(d) Finally, ease in transferring information from one component of the system to another is an essential element in any instructional management system model.

3.0.2 Didactic elements in instructional management

The main characteristics of the *instructional management* models which are set forth above have direct equivalents on the instructional level:

(a) The formulation of instructional objectives corresponds to the initial definition of *needs*.

(b) The definition of steps in student activity in reaching his goals and the determination of his progress in a course* correspond with the definition of steps in developing the system. Testing what the student has learned corresponds to the control operations. This assessment is mad by checking whether the proposed objectives have been reached.

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* In this context course should be interpreted as any instructional sequence aimed at reaching objectives.

(c) The *diagnosis* resulting from the assessment corresponds to the feedback. Depending on his results, the student is offered a selection of activities allowing him either to reach the objectives he has not attained, or to advance toward new objectives.

(d) Finally, ease in transfer of information corresponds to additional means offered the student to enable him to understand the objectives set for him or available to him, know the results of the various tests or exercises, immediately or fairly quickly, and the range of learning activities he can embark on to attain his objectives, and so forth.

3.0.3 Computer applications

In the field of *instructional management* the computer has proved a useful tool thanks to its considerable memory capacity and its data-processing speed. In the following pages we describe three main types of computer use which have developed considerably, especially in the United States:

- *Information banks* make data available concerning the *knowledge* to be transmitted, places where it may be found, the media used in transmitting it and so forth. Generally speaking they play a role in facilitating the transfer of information among the various elements in the educational system.

- Use of the computer in testing facilitates making up and correcting tests and exercises used by the teacher or directly by the student. This type of use itself combines three different applications which we shall define when presenting this use.

- *Computer-managed instruction* makes use of technical and instructional resources set up when the two preceding types of applications are used to enable the teacher and student, in class or alone, to proceed systematically in their teaching or learning activities all within the program of individualized instruction.

3.1 *Information Banks*

3.1.1 Presentation

Here we are concerned with applications in which the computer is used to store or retrieve information. This information may be extremely diverse in nature, and the user of the *information bank* may be either the teacher or the student himself.

This application is also known as Information Storage and Retrieval, or simply Information Retrieval.

3.1.2 Examples

(i) Since 1970, NASA has been operating a scientific information bank (experiment reports) at Park College in Maryland. This system enables the user to define his needs by

3.1.2 ...

typing a few simple orders (keywords or codes). Using these words the computer analyzes the request and presents the citations corresponding to each code or each keyword used in the request. Then the user selects the citation he is interested in and the computer provides him with the sequence number. This number will make it possible for the user to find the corresponding microfiche, consult it or obtain a copy. (14)

(ii) The use of the *information bank* finds its natural application in guidance. At the University of Pennsylvania, for example, students can consult the computer to obtain information on the professions which interest them. Information may concern the salaries, duties, academic prerequisites, and the like, connected with the various professions. (33, p.22)

(iii) At the Massachusetts Institute of Technology (M.I.T.) an *information bank* system has been developed for the students. This system allows students to obtain information in physics, in real or deferred time. The student may carry out his research using keywords or a quotation index; he may also obtain information by specifying the name of an author, the title of a book or article, where an experiment took place, or a combination of these data. (33, p.22)

3.1.3 Instructional aspects

It has become a commonplace to speak of the explosion of knowledge or of the information explosion. This explosion

involves not only the whole of the available knowledge which can be imparted, but also information concerning places where this knowledge is stored, techniques which will make its transmission easier, methods of assessing the efficiency of transmission, and so forth.

Instructional use of *information banks* is intended to facilitate gathering, retention and location of this information. The first three examples quoted above showed computer-managed *information banks*, intended for students. The computer becomes a tool for retreiving the information to be learned. This type of use leaves the student complete freedom.

The same system of questioning the *information banks* may also be used by the teacher to locate information on the course content. There are also numerous examples of using computer-managed data banks to make more efficient clerical tasks carried out by the teacher. For example, "Instructional Objectives Exchanges" in Los Angeles is in the process of setting up an educational objectives bank to enable teachers in every discipline to find without difficulty instructional objectives they may use directly or which will help them formulate their own instructional objectives. This bank is not yet computerized although its creators expect it will eventually be automatic (55).

Another example of the assistance *information banks* management may offer the teacher, is the CTSS* system which among other things makes it possible to produce lists of questions in accordance with the teachers' specifications (43).

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* Classroom Teachers Support System, developed by the Los Angeles City Unified School District and IBM.

The teacher can quickly make up his questionnaires for exercises and tests using these lists.

More generally, and in the sense indicated in the introduction to this chapter, the computer is used as a center and a communications medium for all the data required by the various participants in the school system and all the information generated by the system during its operations.

3.1.4 Another example: UDEANS

A typical example of the instructional use of *information banks* is the UDEANS system developed for the "College of Social Science at Michigan University" (73).

The UDEANS system was developed from a model of communication and instructional resource management in higher education. In their article John F. Vinsonhaler, Daniel Millin and Gerald M. Gillmore first present the model then explain the information system to which it gave rise.

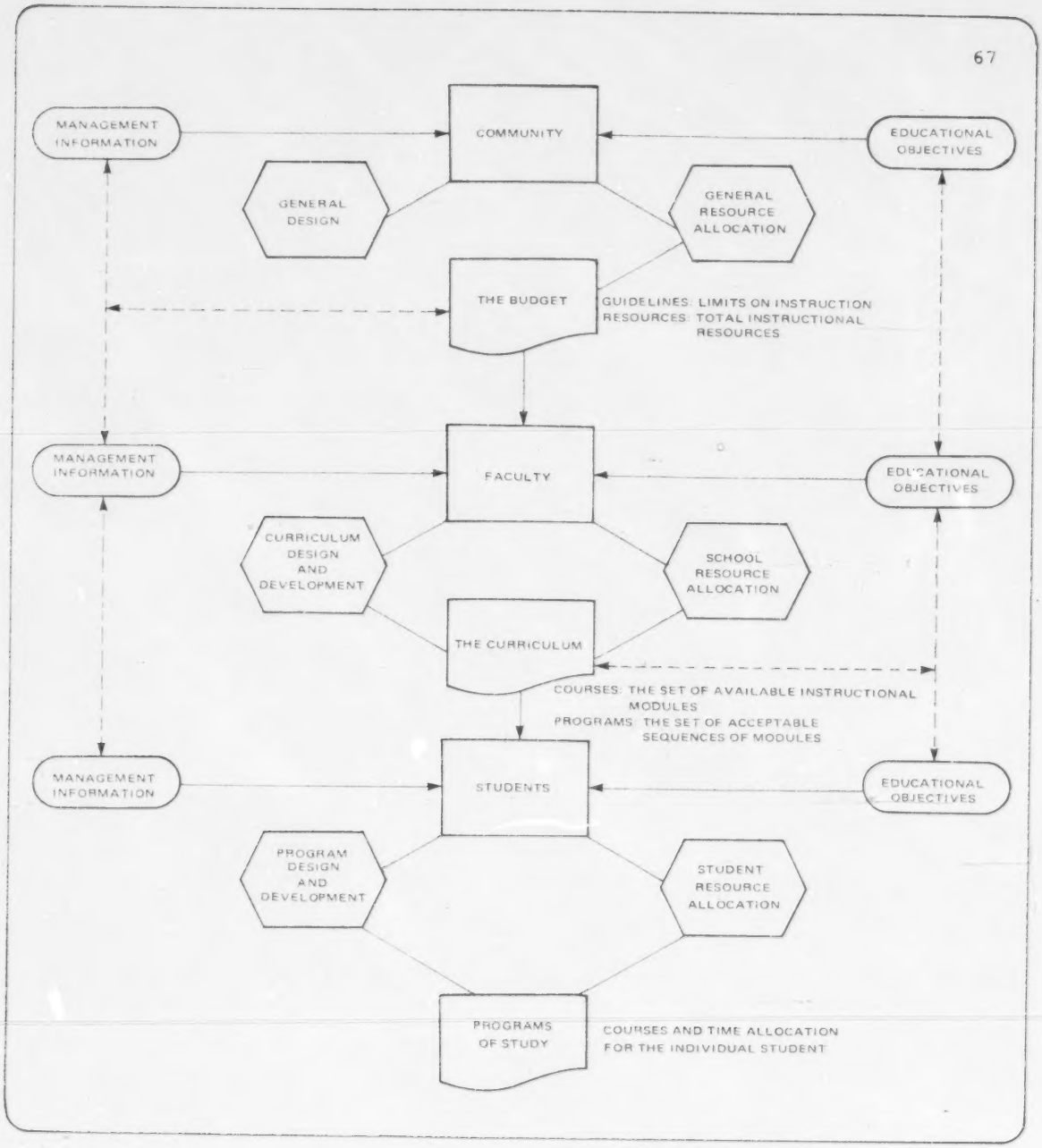
The model considers a school as a simple information system involving communication and decision making within three distinct groups of individuals: *the community in general*, (the group providing the basic educational support), the *faculty* (the group offering basic educational services: administrators and teachers) and the *students* (the group using these services). The model(cf figure 8) assumes that the persons involved in the school system are engaged in

three basic types of management activities:

- instructional design (the selection of educational objectives);
- instructional development (the preparation of an educational program to achieve the objectives);
- resource allocation (the allocation of available financial, human and instructional resources among the various programs of study).

This model has given rise to an information system (cf Figure 9) in which the main components are:

- a computer
- a series of programs making it possible to process files
- data concerning the curriculum (educational objectives, programs of study, available resources and the like as well as the persons involved in the educational system (students and faculty)



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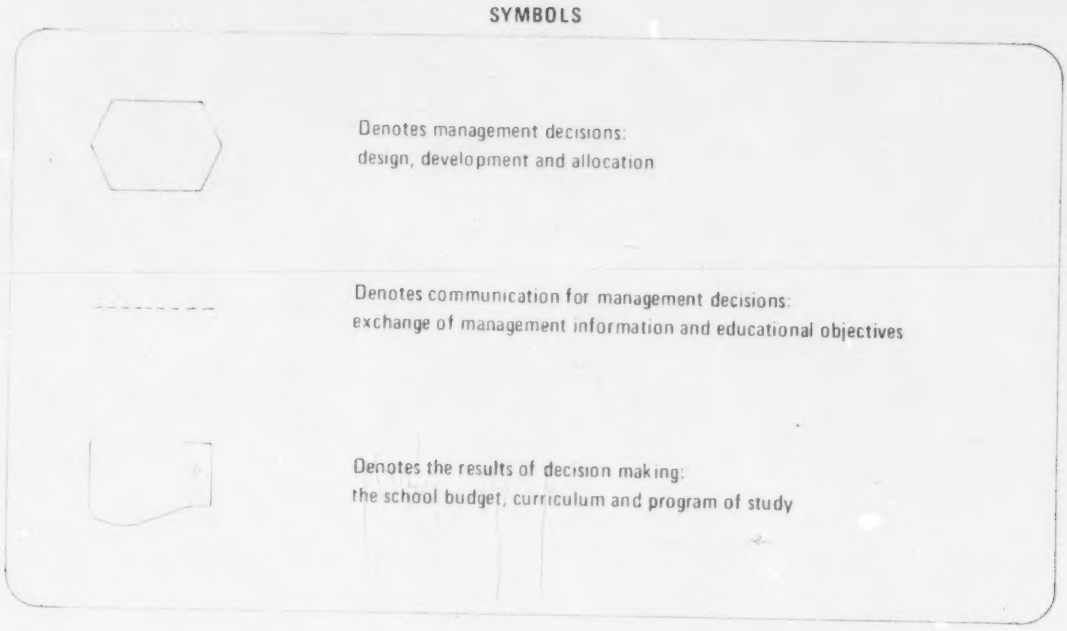
SYMBOLS
Denotes management decisions:
design, development and allocation
Denotes communication for management decisions:
exchange of management information and educational objectives
Denotes the results of decision making:
the school budget, curriculum and program of study

Fig. 8 An information system model for communication and resource management in higher education (73, p. 33)

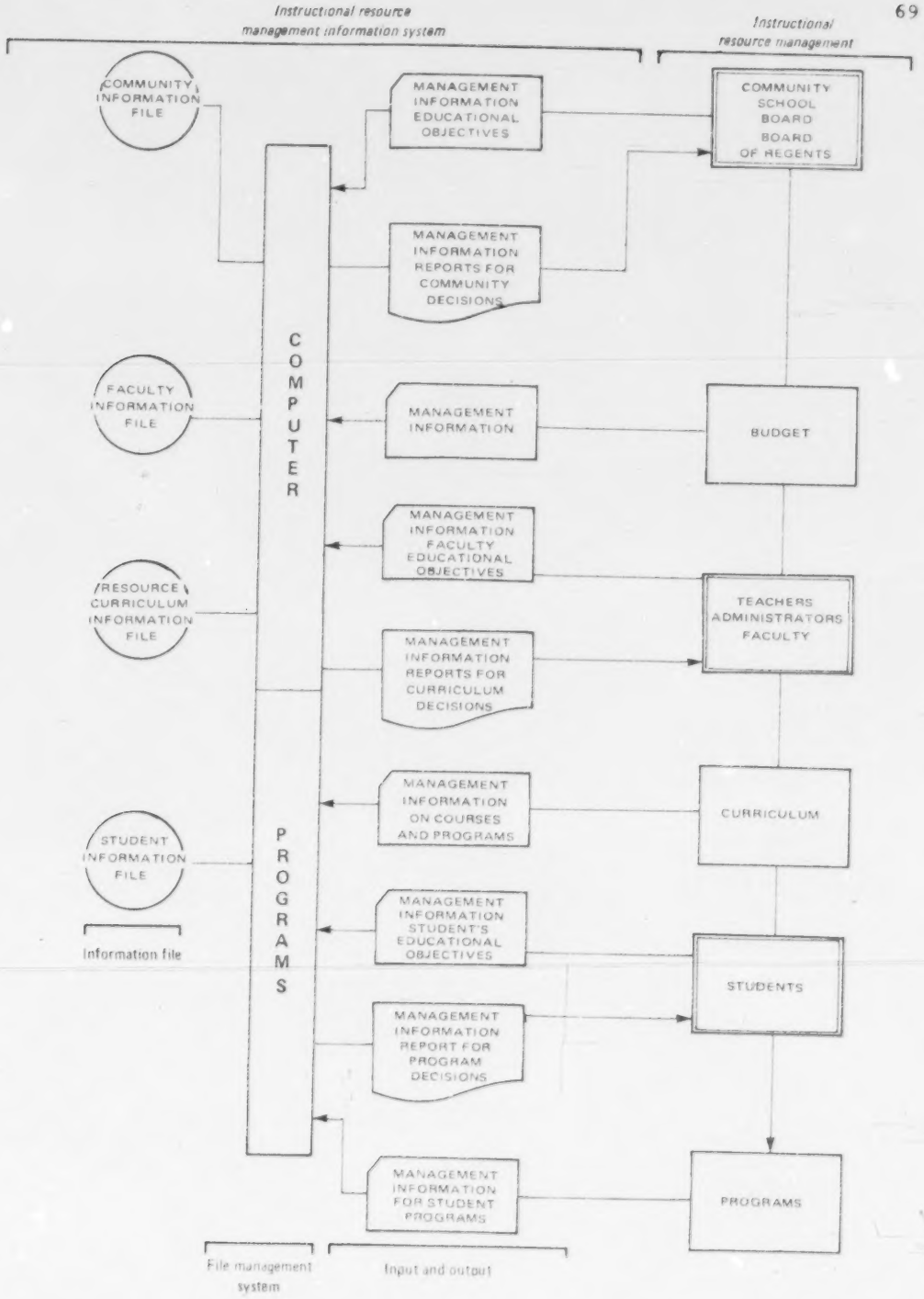

Fig. 9 The Udeans method for instructional resource management by computer (73 p.34)

It is quite evident that the instructional character of the application is determined by the third component, that is, the content of the data processed by the system. As for the first two components, they are to be found in any information system used for administrative or commercial purposes.

The files (or information banks*) processed by the system contain information concerning:

- faculty and students: information of a biographical nature or regarding interest in subjects related to the curriculum;
- programs of study (identification of courses: number, name, cost, equipment required, educational objectives, and so forth).

The informative system generates various reports:

- the educational interest inventory of the students and faculty. The same course may for instance have been considered of very little interest by the students (2.8 on a one to five scale) and very important by the faculty (4.2 out of 5).
- a faculty resource allocation inventory. This report shows the number of students each faculty member is advising,the number of committees on which he serves, or the number of courses he gives.

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* In this text these two terms may be considered synonymous.

- a guide for each student. This guide allows a student to see whether he meets the academic requirements of the courses in which he is enrolled, to know which courses are available to him in the order of his interests, and so on.

Such a system makes it possible to gather, process and transmit information useful to students, teachers and administrators in planning their respective activities.

3.1.5 Technical aspects

The preparation necessary for using the computer for information management, entails in particular gathering, analyzing, structuring and classifying the data to be stored and retrieved. Setting up processing programs (the data processing work in the strict sense of the word), is not the most complicated phase in developing these systems. Keeping the files up-to-date is an extremely time-consuming operation.

In the area of equipment, there are generally three types of facilities.

(i) Batch processing with manual transportation of the requests and answers. In this instance the user does not have a terminal at his disposal. He must forward his requests to a processing center by mail or by internal courier. He receives the response in the same way.

(ii) On-the-spot batch processing. In this case the user has a terminal at his disposal (generally a card reader or printer.)

(iii) Real-time processing. The user has access to a conversational system thanks to a an interactive terminal (generally typewriter-like).

In most cases, when the application is designed for students, data is processed in real time by means of individual terminals.

In the case of use intended for the faculty, (i) and (ii) are used. In the first case, obviously, the time lapse between the request for information and the response is considerably greater than in the second. CTSS, for example, is presently using the first type of system (this is an economic, not a technical restriction, since the number of terminals is thus reduced to a minimum.) A teacher may wait three days after making his request before receiving a questionnaire. If he had a card reader in his school, he would probably obtain his questionnaire the same day.

3.1.6 Experiment results

There are almost no examples of research on the instructional efficiency of using the computer for *information bank* management.

Stanford University has attempted an experiment to measure the attitudes of people using automatic information systems. The users had at their disposal four main controls enabling them to either select an item of information or combine several items, to have them displayed on a cathode ray screen and even to have them printed. Nine people took part in the experiment. A recorded interview resulted in the following appreciations:

- the system's speed saves the user time,
- the fact that data can be combined is an interesting characteristic,
- a considerable amount of time, however, is required to master the system's commands.

A later experiment with 19 users confirmed these appreciations.

Finally let us note that, generally speaking, an *information bank* makes the same amount of data and the same content available to anyone who has access to it and at any time.

3.2 Testing Aid

In individualized instruction, testing plays a central role involving both the student whose progress must be checked and the overall system which must be modified in accordance with the results obtained.

Applications of the computer listed under the heading *testing aid* make the tools to facilitate this testing available to the teacher and the student.

In our classification, we have distinguished between three very widespread types of applications:

- *answer processing*. The computer is used to correct, compile and analyze the results obtained in tests;
- *test generation*. In this case, the teacher (and occasionally the student) has access to a questionnaire bank and to an answer processor. The questionnaires may be used for testing students or as exercices.
- *individualized testing*. In this case the computer is used to generate a questionnaire in which each question is chosen on the basis of the student's previous results.

3.2.1 *Answer Processing*

3.2.11 Presentation

Here a series of programs are used making it possible to correct and compute the students' answers to a questionnaire and put out results which the teacher can use in planning his lessons.

3.2.1.2 Example*

The "Epic: Fast" Program [36] is a good example of the possibilities for using this type of application.

"Epic: Fast" was intended for use in class by the teacher who feeds the computer cards showing:

- his students' answers to one or more questionnaires;
- the correction grid for the questionnaires showing the proper answer to each question;
- the list of operations he wants performed on the data (that is, printing out of results by student, number of students who answered each question properly, correlation between the questions, and so forth). These options are made known to the system through a series of cards supplied by the manufacturer.

The teacher may also have the computer process results of tests already corrected manually, if he so wishes.

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* Because of the relative simplicity of the application, only one example is given.

With such data, "Epic: Fast" will perform the operations desired and will print the results (as tables, curves, histograms) on any of various forms as preferred by the teacher.

3.2.1.3 Instructional Aspects

Answer Processing is a fairly common use of the computer and, in the form described here, involves the teacher in his everyday work. In fact, the correction of tests and questionnaires is certainly one of the most tedious tasks required of the teacher. These tests, however, frequently little more than an attempt to take the class's pulse and to make possible an adaptation of the teaching method,are necessary if the instruction is to be effective. Accordingly there has been much research and system development to provide the teacher in the classroom situation with tools making it possible to use computer resources for the correction and statistical computation tests require. Two types of instructional information can be provided by these programs:

- information concerning the teaching method since the weaknesses of a class in general, or particular groups or individuals can be clearly discerned;
- information on the value of the tests themselves, since the difficulty,the factor of discrimination, and so forth, of each question can be analyzed as can the test as a whole.

Such programs can obviously also become powerful tools in educational research.

3.2.1.4. Technical aspects.

As far as the processing method and the hardware generally

3.2.1.4 ...

used for *answer processing* are concerned, the very nature of the application explains the present use of batch processing and rapid terminals for input/output (card reader and printer).

The statistical programs incorporated with these packages employ techniques which have long been used in traditional statistics and represent no particular difficulty as regards programming.

However, with regard to answer analysis, no system of this type correct other than multiple choice type answers (the true or false type being one special kind of multiple choice). A few programs (rare) will accept numerical answers. There are two main reasons for universal use of multiple choice, which is restrictive from an educational point of view:

- difficulty in correcting open-end questions;
- the necessity (to save time and equipment) of using the card and the optical reader (visual scanner) to record the answers.

3.2.1.5 Experiment results

Use of the computer for *answer processing* is a technical application. Experiments involving the development of this application are generally conducted without the help of the computer. Their purpose is to show the possibility of analyzing open-end answers, the superiority of using answers based on multiple choice questions as regards accuracy of measurement, and so on.

The interest, for the teacher, of programs for correcting answers, computing and statistically processing results is obvious, and has not been subject to any research as such. This type of use is associated particularly with the application of *test generation* and *individualized testing*, and, from the viewpoint of the actual analysis of the answer, instruction through *dialogue*.

3.2.2 *Test generation*

3.2.2.1 Presentation

In this case the computer is used to put out and correct previously determined series of questions.

3.2.2.2 Examples

(i) At the Ecole Polytechnique in Montreal a *test generation* system has been set up to allow teachers to obtain at any time questionnaires, for a particular test and for one or more students, which differ in form (for example in the choices given) but test the same behavior .

The system enables the teacher to introduce his questionnaires on a file, retrieve them as needed, have the answers which the students give on cards corrected and the results of the questionnaires printed. Obviously, the questionnaires prepared by the various teachers can be used by any member of the faculty.

All the questions (even those requiring a numerical answer) are multiple choice [40].

(ii) During the 1971-72 school year, Mr. Gérard Delord experimented with a type of computer testing at the Académie Saint-Louis in Québec City. Questionnaires related to the objectives of a physics course were stored in . file. The students were questioned and replied with the ITF conversational system. All the questionnaires comprised the same questions. The conversational system permitted the use not only of multiple choice questions but also of questions requiring numerical answers. Moreover, after each reply, the students at once received a comment to confirm their success or show their mistake. [15]

3.2.2.3 Instructional aspects

A test is not a list of questions selected at random from the whole range of questions dealing with the same subject. A questionnaire (for testing purposes) is a planned set of questions to check whether known objectives have been attained (the objectives of a particular area of instruction). In the first example we gave, the teacher could specify the specific subject on which he wanted the questionnaire, and the degree of difficulty of the questions. The level of the objectives measured could be another variable.

Questionnaires are generally produced and corrected in two different ways depending on the eventual use.

- Many systems have been devised to lighten the teacher's task by making available to him prepared question sheets which are corrected automatically, with the results presented in a form that may be used directly to guide instruction(cf. first example);

- Other systems make it possible for the student to be tested directly by the computer. Generally this type of testing allows a type of corrective instruction through the immediate comments the student can receive (cf. second example).

Obviously, the questionnaires produced may also be used as exercises for the students.

3.2.2.4 Technical aspects

Test generation technically speaking is merely a special use of the question bank, combined with a possibility for processing the students' answers. The technical aspects described for these two uses (3.1.5 and 3.2.1.4) are applicable here.

The use of a conversational system for *test generation*, however, permits considerable flexibility as to the availability of questionnaires and the use of open-end questions or even questions made up by the students. It also makes immediate feedback possible.

3.2.2.5 Relationships with other applications.

We discussed the management of question banks in presenting the *information bank* application. In this application, the user may request questions with certain specifications. However, the information he receives does not strictly speaking constitute a questionnaire, but a simple list of questions which he can subsequently

3.2.2.5 ...

use. The CTSS* system is a question bank management system. However it can be used for *test generation*. With the questions provided by the system the teacher, in fact, may make up one or more questionnaires which will be preserved as such by the computer. From the first list of questions generated by the computer the teacher can eliminate some, add his own questions and so forth. He then sends his selections to the computer. The particular questionnaire thus established and stored in file may be reproduced as often as required. It is easily seen that the teacher uses the computer to consult a question bank, from which he obtains information of interest to him.

Applications which allow *test generation* on the other hand give the teacher a finished product (questionnaire) which can be used immediately to test an individual or a group.

3.2.3 *Individualized testing*

3.2.3.1 Presentation

In this case each question is selected for the test on the basis of the students previous results.

This use is often called "Computer-Assisted Testing" CAT or "Computer Based Testing".

3.2.3.2 Example

Richard L. Ferguson of the Learning Research and

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* Classroom Teachers Support System described briefly in 3.1.3.

3.2.3.2 ...

Development Center (LRDC) of the University of Pittsburgh presents an application of *individualized testing* in an article published in *Education* (23). The subject of the test was primary level arithmetic.

Once the educational objectives for the course in question were determined they were classified in a hierarchy indicating prerequisites.

In Figure 10, objectives 1, 4 and 7 are prerequisites for objective 10. Likewise if objective 10 is not mastered, it may be concluded that neither are objectives 12,13,14,16 and 17. In this example, objectives 6,17 and 18 are terminal, that is they are not prerequisites for any other objective.

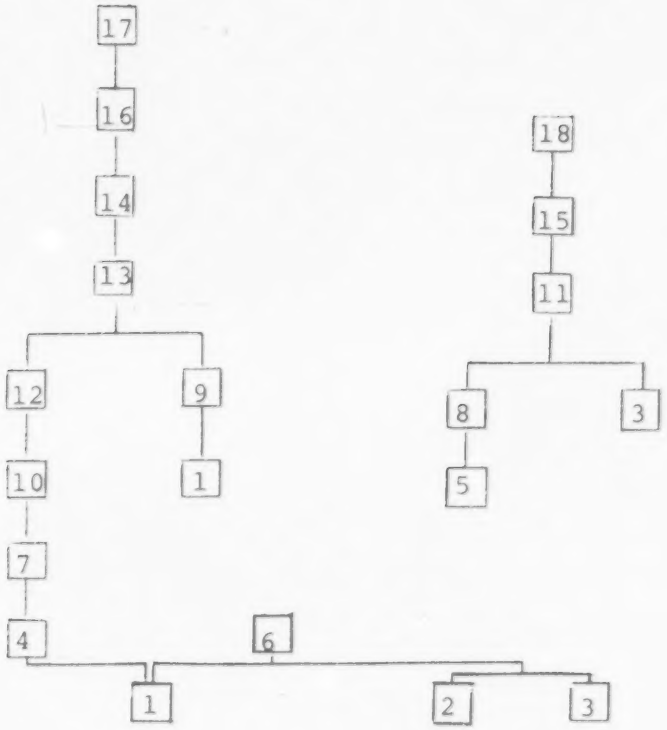

Fig. 10 - *Example of objectives hierarchy for individualized testing.(23)*

3.2.3.2 ...

As soon as such an objective hierarchy is considered valid, it is no longer necessary to assess whether each individual objective is reached. Questions are produced at random and, depending on the student's answer, another position may be chosen in the hierarchy to test certain prerequisites for this objective. Success or failure in certain objectives may be assumed without necessarily testing them. The system includes the following components.

- the generation of test items from a question bank,
- a program making it possible to decide whether an objective has been reached (by probability analysis)
- a program making it possible to take another position in the hierarchy (by branching) to avoid having to test each objective.

The student answers the questionnaire at an individual terminal. Every student answers a different personalized questionnaire. This testing technique has made it possible to reduce considerably the duration of a conventional test and the number of questions asked. *

3.2.3.3. Instructional aspects

In a form of instruction with increasing individualization of educational resources, testing assumes an ever-growing role. It produces the data necessary for the decisions which must be made by teachers, students and personnel concerned with programs and preparation.

This is why in programmed learning with prepared texts and, as we shall soon see, in *computer-managed* or *tutorial* learning, tests are frequent and exacting, and require a considerable percentage of the student's time. These successive and continual tests often tend to slow down the progress of a course.

The use of a computer in *individualized testing* makes it possible to reduce the duration of tests and generate them on an individual basis while preserving the accurate measurement of traditional testing.

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* R.L. Ferguson's experiment is written up in report no. 8, section 3.5.

3.2.3.4 Technical aspects

Individualized testing as presented here requires the use of a conversational language and an interactive terminal.

The information components of such a system are approximately the same as those of the *test generation* system: a question bank, test generation programs, answer processing and computational programs. It should however be noted that the use of a conversational language and interactive terminals facilitates the use of composed answers (as opposed to simple multiple choice). This additional feature although making the application more complex permits its use in fields where multiple choice restricts the scope of the tests.

3.2.3.5 Experiment results

Achievements in *individualized testing** bring out unequivocally the following two aspects of the application:

- it allows a considerable decrease in the length of tests.
- it is a reliable technique for testing, that is, the results obtained by students on an individualized test are comparable with their results on a traditional test with up to twice as many questions.

The computer plays a central role in *individualized testing* demonstrating the interest of the interactive systems without which this application would be of little use.

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* Reports 6,7 and 8

3.2.3.5 ...

There are numerous advantages generally recognized in this type of application:

- The student receives his results at once.
- The length of the tests is decreased by a third, sometimes even by half.
- The student is questioned according to his previous results; this avoids repeated failures due to tests too advanced for him. On the other hand the better student does not have to waste his time on questions which are too easy.
- The computer stores the results obtained in its memory, processes them and can then produce data enabling the teacher or student to make decisions concerning his activities.

3.3 *Computer Managed Instruction*

3.3.1 Presentation

In this case the computer is used to manage all the resources at the student's disposal and guide his progress towards the objectives he is pursuing. In some cases the teacher uses the computerized data and is responsible for management, in others, the computer itself performs this job.

In this application, the computer is used to process instructional data (objectives, tests, teaching material, performance, and so on). It may:

3.3.1 ...

- manage objective banks;
- generate and correct questionnaires;
- keep track of a student in a course by memorizing his performance or the point he has reached in the course;
- diagnose the student's past activities or suggest new activities which will enable him either to advance in his course (or program of studies), or resume activities in which he has not yet reached his objectives.

Today there are two main methods which can be distinguished in designing *computer-managed instruction* systems. In the first case the computer is used to furnish the teacher with the necessary information for effective management of student activity in individualized group instruction. In the second, the student comes into direct contact with the computer. The latter gives him tests, corrects them and sets the task he should undertake.

3.3.2 Example One

A well known system in this field is the Westinghouse Learning Corporation's PLAN* system. PLAN is an example of a *computer-managed instruction* system made available to the teachers in the traditional classroom setting.

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* Program for Learning in Accordance with Needs.

3.3.2 ...

(a) The Computer's role

In PLAN, the student does not come into direct contact with the computer. The only contact he has is by means of cards which he must fill out periodically.

The computer is a tool to be used by the teacher. William M. Shanner explains the computer's role as follows:

> "The Computer becomes an informational system which records the student's learning and academic history and his program of studies, scores the tests and examinations, and furnishes on a retrieval basis this information back to the teacher. In other words, the computer is concerned with the non-instructional or managerial aspects of the program" [62, p.1].

(b) Instructional material and the individualization of instruction

In PLAN, the student learns through programmed texts, audio-visual material and individual or group activities which may be directed by the teacher or not. At the end of each day, the student must indicate (by filling out a card) the point he has reached in his program activities. Every morning, the teacher receives from the computer a complete report on each person in his class, as well as information pertaining to the activities planned for the day, cases where certain students would require special attention, the results of tests taken by some students the day before and so forth. The computer's clerical work thus makes it possible for the

3.3.2 ...

teacher to direct each student individually.

The instructional material used was not designed specially by or for PLAN. Greater attention is paid to the use of the already existing material.

The basic instructional unit in the PLAN project is the TLU ("Teaching-Learning Unit"). A program of studies for a particular student consists of a number of these TLU's. A certain number of instructional objectives, activities to enable the student to reach these objectives, and tests to measure whether the specified objectives have been reached, are associated with each of these TLU's. It generally takes a student two or three weeks to complete a TLU. A great deal of latitude is allowed the student in choosing in what order he will perform the various tasks associated with a TLU. At the high school level, there is even an attempt to allow the students themselves to plan their choice of objectives and activities.

The PLAN system has been commercialized in the United States. Its use is now concentrated at the elementary level although its promoters intend to extend it to the secondary level.

3.3.3 Example two

Whereas in PLAN, the computer is a tool in the hands of the teacher, in another experiment, at the University of Florida, [17] it was decided to place the student in direct

3.3.3 ...

contact with the computer. In this experiment, the type of computer use is described as follows:

> "It assumes that a student will achieve his maximum performance level by interacting *directly* with the computer in order to evaluate his learning experience, i.e. the computer should play the role of real-time diagnostician and prescriber for the student, as well as a master record keeper for the entire student population in a particular instructional program" (17, p.33).

The project promoters wished to individualize the course on programmed instruction techniques, already offered by the University as a lecture course. The main steps in setting up a course using *computer-managed instruction* were:

- *analysis of the problem:* the question was to determine whether the project was economically and pedagogically worthwhile;

- *analysis of tasks;* it was necessary to determine the tasks which students should be able to perform at the end of the course;

3.3.3 ...

- *determination of prerequisites;*

- *formulation of instructional objectives:* at least one and at the most three objectives were defined for each task or subtask;

- *drawing up the test questions:* fifteen items were written for each objective;

- *planning the course:* this involved determining the sequence in which objectives would be pursued;

- *choice of media:* selection of media (texts, articles, slides, films, tapes) depended on instructional material already in existence.

The course itself is set up as follows: the organization of the course is explained to the student during the first period.* This is the only formal *lecture* in the course. Students then go to the audio-visual or computer center when ever they wish to study or be tested. When a student has finished studying a task in the course, he answers a five-question test at the terminal. Depending on the results, the computer recommends that he goes on to another task or review the

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* It should be noted that in this case the application is used within a traditional university time-table.

3.3.3 ...

material involved in the task for which he has just been tested. Thus the student progresses at his own pace and can organize his own time-table.**

3.3.4 Instructional aspects

In a context of individualized instruction as practised or advocated at all levels of education today*, "a typical teacher who might be responsible for 50 or more students in at least two different courses, with 30 teaching-learning units per course, has no fewer than 3,000 media assignments to make "(72). These should be based on the academic background of each particular student, his aptitudes, tastes, learning pace and so forth. As a further complication, in such a context the students do not pursue the same objectives at the same time.

There are several *computer-managed instruction* systems of the PLAN type. Many experiments have also been

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** For the costs of setting up the system, as well as a comparison between these costs and those incurred for lectures in the same course, the reader may refer to Volume II, Page 46.

* The reader has merely to refer to the idea behind Regulation No 1 respecting primary and secondary levels and to pilot experiments such as that of the CEGEP Montmorency on the college level.

3.3.4 ...

tried in *computer-managed instruction* systems like the one described in the second example mentioned above. In spite of the marked differences between the two systems, the techniques used in developing them show great resemblances.

When describing the Florida State experiment, we listed the steps in the development of a course using *computer-managed instruction*. According to William M. Shanner, the main instructional features of the PLAN system are as follows:

- a series of specific instructional objectives defining the tasks that the student will be able to perform at the end of his study;

- a series of learning activities by means of which the student will be able to accomplish assigned objectives;

- programs to test whether the student has reached the objectives. The questions or activities required of the student as tests are directly related to the instructional objectives, so that a test does not attempt to assess whether a particular part of the instructional material has been learned but whether the specified objectives have been attained.

3.3.4 ...

This information is contained in banks (objective banks, reference banks, question banks) and the existing relations between these data might be represented as follows:

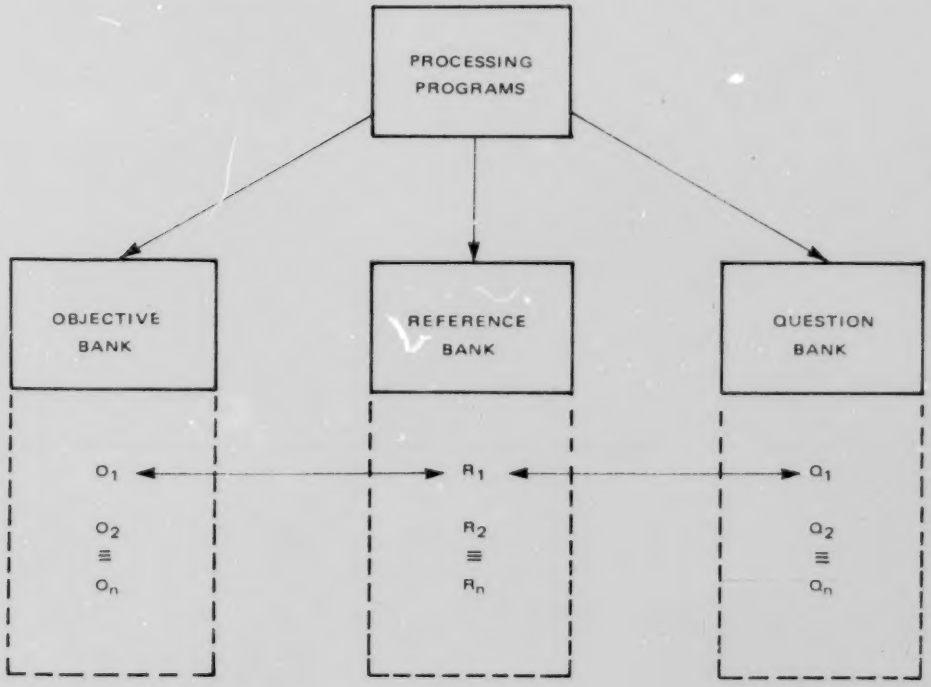

Fig. 11 Relationship between data contained in the various banks of a computer-managed instruction system.

3.3.4 ...

It should be noted that several documents or types of activities may conceivably lead to a particular objective. Likewise a number of questions can be used to determine whether the same objective has been reached. In Figure 11, the letter "R" (references) is used to designate all the references to any teaching material which makes it possible to reach the corresponding objective [O]. The letter Q (questions) is used to designate all questions with which it is possible to test whether the corresponding objective has been attained.

The computer system strictly speaking, includes only the elements identified in Figure 11 as *processing programs*. The data on instructional resources consolidated in the various information banks may exist and in many cases do exist by themselves. In PLAN, for instance, the project promoters insisted on the fact that the system used material available on the market.

In Figure 12 may be seen an illustration of a complete *computer-managed instruction* system. In this

3.3.4 ...

illustration, components (a), (b) and (c) of the system correspond with the *processing programs* identified in Figure 11. These programs are used to manage the *information banks* on the system's instructional resources (objectives, references, questions), as well as the bank containing the academic status of students (point reached in its program, tests results, and the like). Figure 13 illustrates the steps in student use of the system (by himself or through his teacher). This illustration should be interpreted in relation to Figure 12.

It should be noted that the processing programs (in particular (b) and (c)) comprised in the system have already been studied in the presentation of the following applications:

- *information banks* (3.1)
- *answer processing* (3.2.1),
- *test generation* (3.2.2)

Computer-managed instruction systems may be developed and set up in successive stages in which the identification and preparation of instructional and computer resources is carried out progressively. It is thus possible to effect assessments and revisions leading to quality and effectiveness in the overall system.

The existence or lack of validated tests and objectives and the availability of instructional material at the moment of setting up *computer-managed instruction* system will affect its cost and effectiveness.

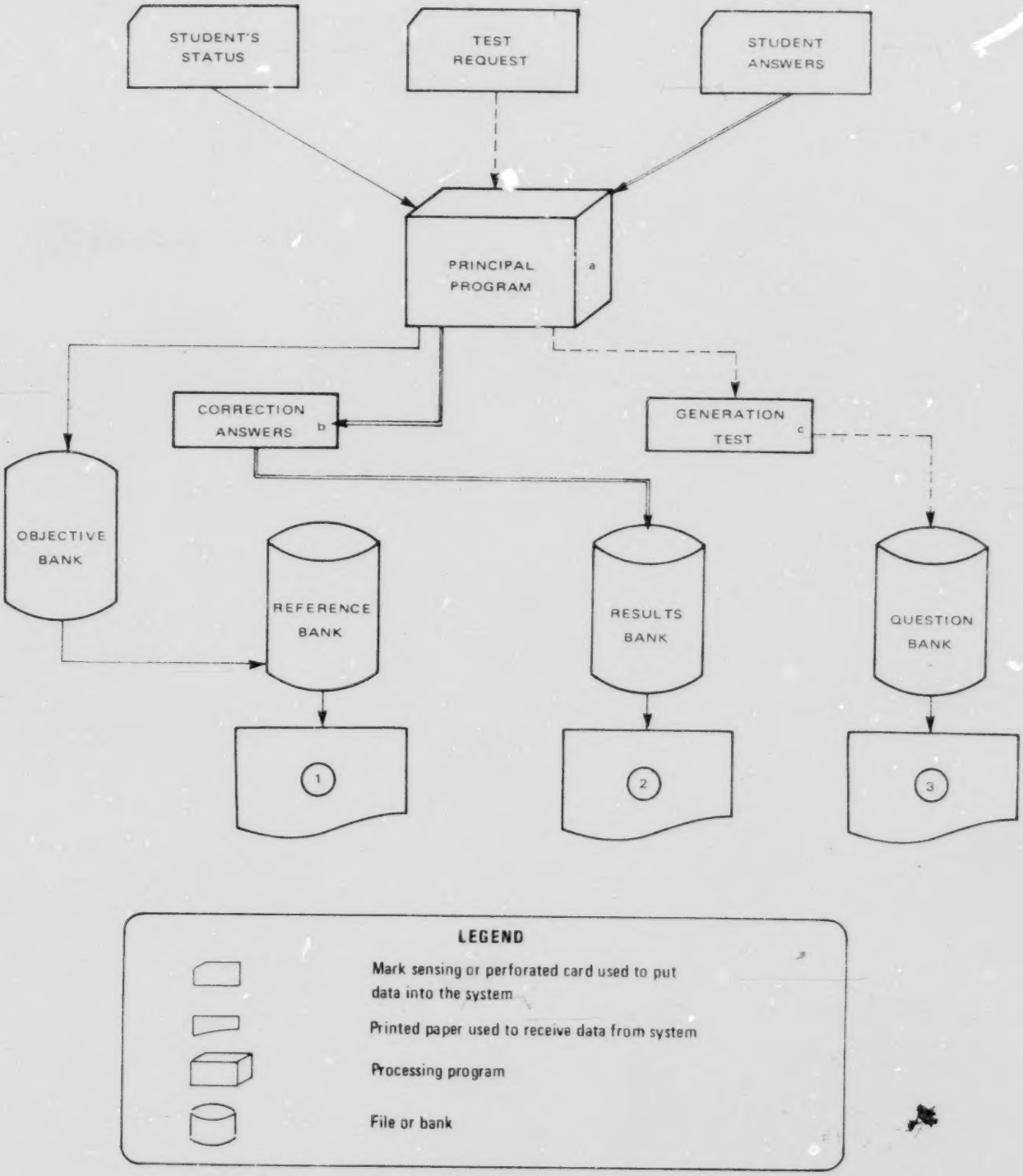

Fig. 12 Illustration of components of a computer-managed-instruction system of the plan type

LPI Report, 1973, vol. I

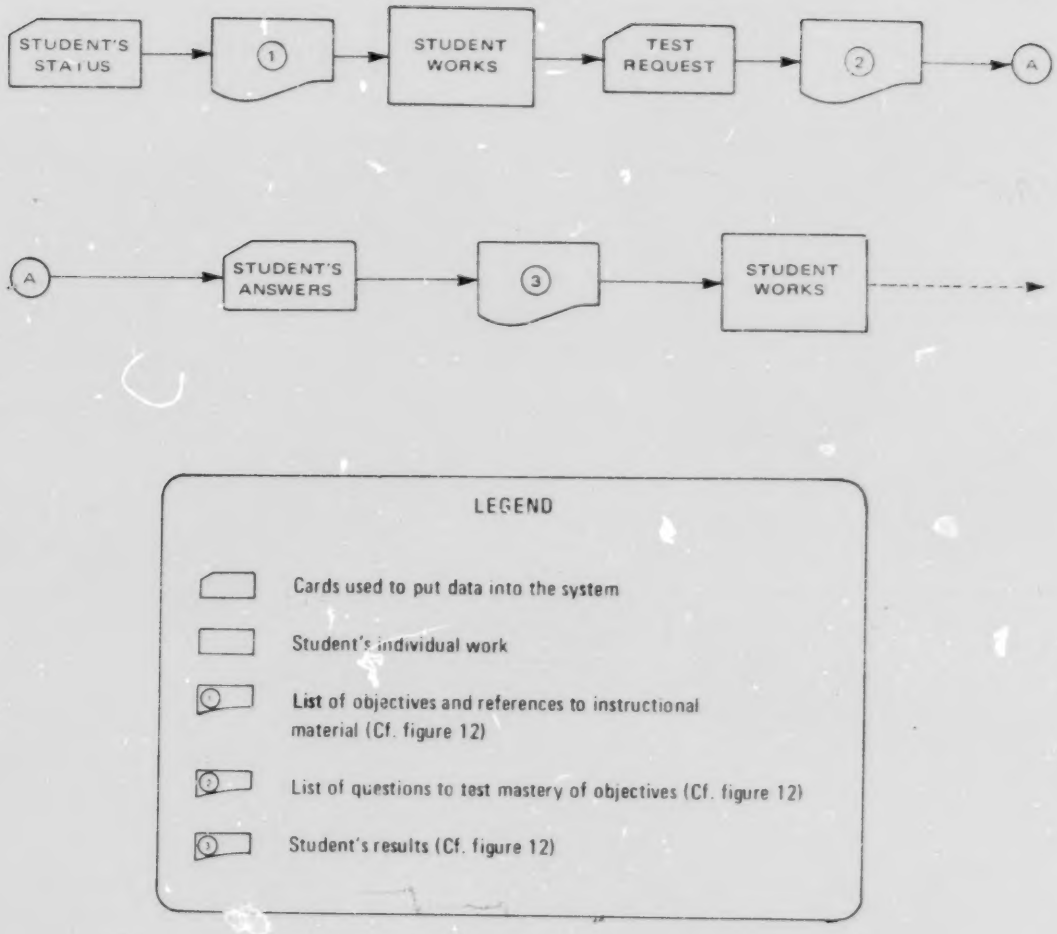

Fig. 13: Illustration of the steps in using a computer-managed instruction system.

3.3.5 Technical aspects

Most *computer-managed instruction* systems now in operation or commercialized in the United States are PLAN type systems for indivualized instruction in groups.

These systems use remote batch processing. The fact that the computer's work is done outside normal class hours (in the evening or at night) makes it possible to use the computer at off peak periods. This feature reduces the costs involved in using the computer. Generally speaking a card reader and printer or a typewriter-like terminal is used. The use of *computer-managed instruction* in a classroom requires only one terminal (card reader-printer) for a large number of students.

In applications where the student is in direct contact with the computer (individual *computer-managed instruction)* a conversational system and a typewriter-like terminal, are generally used for testing. The advantage in using this type of terminal* is that it enables the student to keep a record on paper of his interactions with the computer during his test. He also keeps a list of the reviews or new activities prescribed by the computer.

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* As opposed to the cathode screen terminal, for instance.

3.3.6 Experiment results.

Although experiencing a rapid development, *computer-managed instruction* systems have not given rise to a great number of controlled experiments. There could be two reasons for this situation:

- A relatively new application of the computer is involved (1968-69 at the earliest),
- The complexity and extension of material and instructional resources involved make any experiment long and arduous.

Experiment report no 9 relates an experiment attempted at Florida State University. Although very limited, the experiment produced encouraging results concerning *computer-managed instruction*.

The largest *computer-managed instruction* systems like that of the Westinghouse Learning Corporation (PLAN) require considerable resources. Assessing the effectiveness of such a project cannot be limited to measuring the pupil's academic performance. The attitude of students and teachers toward the system, the organizational changes arising from its implementation in the school, its social and economic impact must all be taken into account.

The PLAN project, for instance, is now being

3.3.6 ...

systematically assessed. The results of this study are not yet available. However, previous studies [64,65] on the classroom attitude of teachers and students involved in the project, seem to indicate that their roles and types of activity changed considerably as compared with a traditional situation. Thus, in accordance with the goals of the PLAN project, the student spends more time planning his work (studying objectives, establishing strategies, and so forth), working by himself on individual material and discussing with his peers. For the teacher, imparting information is becoming less significant. For instance, he spends more time analyzing his students behavior on the basis of the data received from the computer, making diagnoses and discussing with his students.

3.4 *Instructional Management Tool* - Conclusion

Because of the services they render the student, the teacher, the administrator and the educational planner, applications of the computer as an *instructional management tool* are very rapidly expanding, especially in the United States.

In this field, however, as in the case of *laboratory tool* applications, developments in computer and educational technology are more rapid than research on the systems they produce. On the other hand, as a general rule, developments in *instructional management* applications are more systematic within a particular field, than in many other computer applications. They have inherent guarantees with regard to the controls over the introduction of the resources necessary for using the computer. There is a greater probability that these systems be set up with a view to the human, educational and economic restrictions of the context into which they are introduced.

Although the use of the computer as an *instructional management tool* is quite recent and accounts for only a limited proportion of the instructional applications of the computer, considerable growth in this use is to be expected over the coming years. This prediction is based mainly

3.4 ...

on the following considerations:

- the movement has already begun in the United States where *computer-managed instruction*, in particular, is increasingly popular;

- most of the applications discussed in this section are easily introduced into the current educational context without major upheavals in the school set up and the selection of instructional resources;

- the present state of our knowledge on educational and computer technology, as well as the availability of equipment would allow relatively inexpensive applications.

3.5 Experiment reports

REPORT NUMBER 5

INSTITUTION CONCERNED : Académie St-Louis, Québec

USE : *Test generation*

LEVEL : Secondary IV

SUBJECT : Physics: Mechanics

REFERENCE : [15]

COMMENTS :

All the course subject material was given with videotapes and written texts. The whole course involved 11 lessons.

At the end of each lesson, the students took a test at a terminal (TWX) hooked up with the SIMEQ computer. The ITF system was used.

Multiple choice questions and numerical questions were involved.

RESULTS :

Using the University of Pennsylvania test the author found that:

81 percent of the pupils were satisfied with the course;

56 percent thought that the method was better than that used in traditional courses;

89 percent considered that this was an effective way of using the student's time.

REPORT NUMBER 6

INSTITUTION CONCERNED : University of Pennsylvania

USE : *Individualized testing*

LEVEL : University

SUBJECT : Music

REFERENCE : [16]

COMMENTS :

Students were presented with four 20-question tests:

1 to identify the missing notes in a musical excerpt;

1 to explain a change in rhythm;

1 to indicate the faults or improprieties of the performer's interpretation;

1 to classify excerpts by historical period.

Every fourth question in the series was presented to the student until the first error. The test then went back three questions; the following questions were presented one by one until the next error. The test ended at that point.

The questions that were less difficult than the question where the second error occurred were considered successfully answered and the more difficult questions were considered incorrectly answered.

RESULTS :

The students required between 15 and 60 minutes to take the four tests on the computer.

By traditional methods 70 minutes were required to take the four tests, not counting several hours for correction.

REPORT NUMBER 7

INSTITUTION CONCERNED : University of Florida

USE : *Individualized testing*

LEVEL : University

SUBJECT : Techniques of programmed instruction

REFERENCE : [17]

COMMENTS :

This was a course taken by 59 students. The subject material was divided into a hierarchy of 20 tasks. For each task:

- Five questions were selected at random from among 15, to check whether the cognitive objectives had been reached, the criterion for success being four correct answers.

- A series of questions on a particular criterion made it possible to test whether the productive objectives had been reached.

The students were divided into four groups:

Group I : In this group the students proceeded through the 20 tasks in an assigned sequence. The behavior results and the test results were assessed by course assistants.

Group II : In this group the students proceeded through the 20 tasks in the assigned sequence, but, after interactive dialogue with the computer they themselves decided whether they had succeeded or not before going on to the next task.

Group III : In this group the students performed the 20 tasks in any order they wished. Their results were assessed by a course assistant.

Group IV : In this group, too, there was free choice of order. After interaction with the computer, the students themselves decided whether they had succeeded or failed.

RESULTS

After the first thirteen tasks the students took an examination to check whether cognitive objectives had been reached.

There was no significant difference among the four groups in either marks (94.4/118 or 80%) or the number of days required. (42)

RESULTS OBTAINED AFTER THE FIRST 13 TASKS:

GROUP	AVERAGE	STANDARD DEVIATION
I	95.80	4.46
II	95.27	5.53
III	92.14	9.15
IV	94.73	4.33

NUMBER OF DAYS TAKEN TO COMPLETE THE FIRST 13 TASKS

GROUP	AVERAGE	STANDARD DEVIATION
I	42.80	4.77
II	41.87	5.71
III	43.20	2.62
IV	42.64	4.85

Finally the results on an attitude test with 200 points varied between 95 and 172 with an average of 142 and a standard deviation of 15. According to the authors, this indicated a positive attitude toward the course.

REPORT NUMBER 8

INSTITUTION CONCERNED : University of Pittsburgh

USE : *Individualized testing*

LEVEL : Elementary

SUBJECT : Mathematics

REFERENCE : [23]

COMMENTS :

The experiment was based on an instruction unit with 18 graded objectives. This unit was part of 80 which made up the mathematics program for grades one to six, a total of 400 objectives.

Since the number of test questions for the 18 objectives could vary between 55 and several million, it was neither practical nor efficient to test all the questions for a particular objective. As a result, to test a candidate's mastery of an objective, questions were generated until a decision could be made with an arbitrarily-fixed risk of error. Thus, if after "n" questions, the student's level could not be determined, a new question was generated. The number of

questions required to reach a decision for any objective was a random variable depending in part on the candidate's true proficiency in objective.

Sitting at the terminal the candidate typed his student number and the date, and this acted as a basis for random number generation. Then a question was presented to him at random; depending on his answer and the rules in the table reproduced below a new question was then asked.

DECISION FOR 1 SKILL	PUPIL'S RESPONSE DATA (P)	BRANCHING RULES (NEXT SKILL TO BE TESTED)
MASTERY $P \geqslant .85$	HIGH $P \geqslant .93$	Branch *up* to *highest* untested skill
	LOW $.85 \leqslant P < .93$	Branch *up* to skill *midway* between this skill and highest untested skill
NON-MASTERY $P \leq .60$	HIGH $.43 < P < .60$	Branch down to skill *midway* between this skill and *lowest* untested skill
	LOW $P \leqslant .43$	Branch *down* to *lowest* untested skill

Example of branching rules for computer-assisted placement testing.

This test was administered to a sample of 75 students from grades one to six in an experimental elementary school. On two different occasions each student was given the test at a terminal connected with an IBM 360/50 computer at the University of Pittsburgh.

Among the students tested, some already knew the subject matter, others were studying it, and others had not yet begun it. After completing the whole test at the terminal, students were questioned in writing on all the objectives which had not been tested at the terminal. There was thus a measure of their proficiancy in each objective.

The results were used to:

- establish the validity of the hierarchy of objectives,
- study the validity of the branching decisions from one objective to another,
- examine the reliability of the test, by the test-retest method.

RESULTS :

The hierarchy was found to be valid. Examination of 150 results showed that in 99% of the cases, the computer-assisted test had accurately predicted the candidates' proficiencies on objectives not tested by computer.

On the average 30.4 minutes were required for the computer test the first time and 28.6 the second,

instead of 75 minutes for a conventional test.

On the average, only 7.11 of the 18 objectives were tested at the terminal the first time, and 6.99 the second. The longest series tested 10 objectives, that is, 55 percent of the number required in a conventional test; the shortest tested 5, that is, 28 percent of the number necessary in a conventional test. Fifty different branching routes were followed during the experiment, an illustration of the flexibility of the system.

On the average only 52 questions were necessary instead of the 150 required by a conventional test (the minimum was 33).

REPORT NUMBER 9

INSTITUTION CONCERNED : University of Florida

USE : *Computer-managed instruction*

LEVEL : University

SUBJECT : Health sciences

REFERENCE : [41]

COMMENTS :

The class consisted of 167 students. 41 acted as a control group and received traditional instruction in class (group A). The others were randomly divided into three groups (B,C,D).

For B,C and D, the course was divided into 14 modules with a total of 32 objectives. Out of 15 questions five were selected at random to form a posttest to check the mastery of each objective of a module. The success criterion for a module was 80%.

In the first computer group (group B) the student who did not master an objective was given additional information and another test.

In the second computer group (group C) the student who did not master an objective received additional

information only.

In the third computer group (group D) the student received no additional information or test.

RESULTS :

In the final test, the results of the students who had used the computer (groups B,C,D,) were better than those of group A. The authors attributed this greater proficiency to knowledge of the objectives and frequent tests.

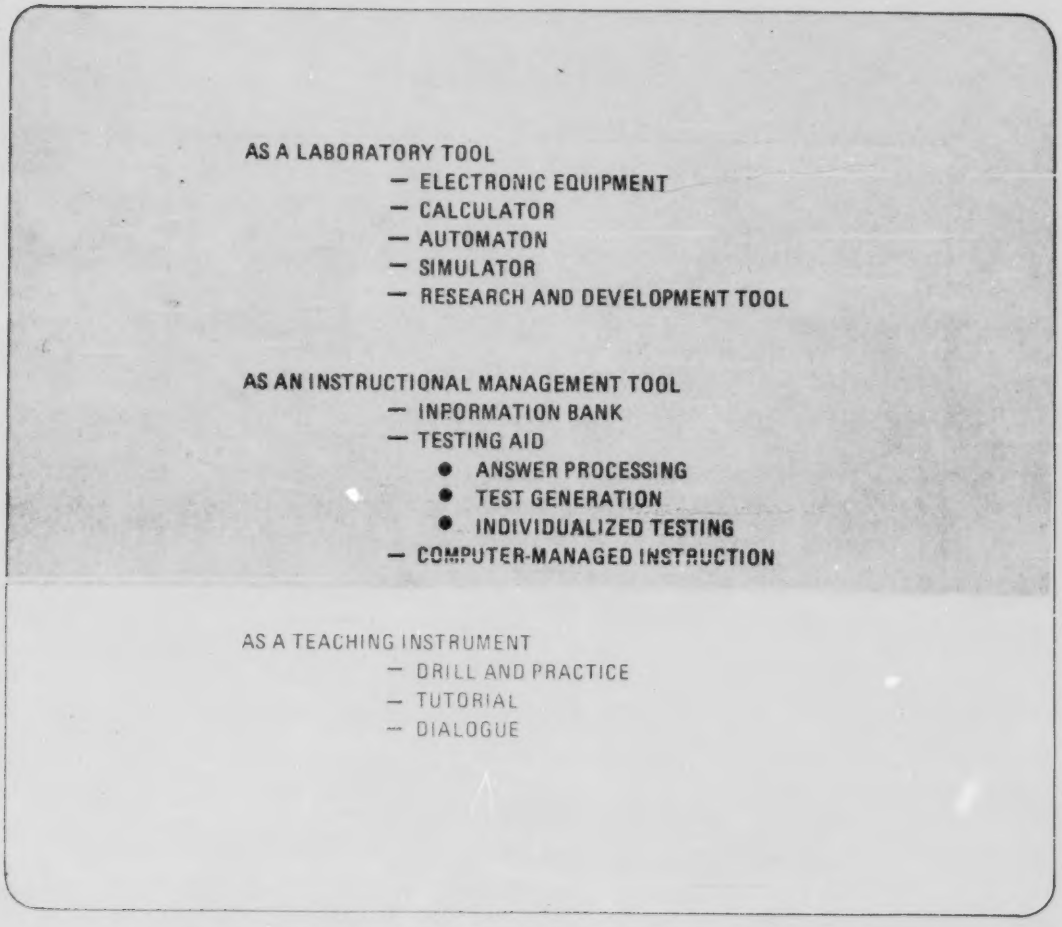
Again in the final test, the first computer group (group B) succeeded better than the others.

No significant difference in the learning time was recorded among the three groups using the computer (B,C,D).

Group C spent less time at the terminal and the difference as compared with group B and group D was significant.

The students using the computer (groups B,C,D) spent an average of 3.5 hours at the terminal. Control group students (group A) spent 30 hours in class.

CLASSIFICATION OF THE INSTRUCTIONAL USES OF THE COMPUTER



CHAPTER 4
THE COMPUTER AS A *TEACHING INSTRUMENT*

4.0 Introduction

The historians of programmed instruction trace its origins back to antiquity. Without going quite that far, it may be noted that in 1936 between 600 and 700 teaching machines had been patented in the United States (29).

In the years immediately preceeding the introduction of the computer in education, research in educational psychology and pedagogy led to the statement of certain laws (the laws of reinforcement, the law of transfert and so on) and the ability to measure the effect of numerous factors on the learning process. This research, along with the development during the Second World War first of linear programmed learning (Skinner) and then of branching programmed training (Crowder), showed that teaching could be automated to some extent.

Finally, notable technical developments in telecommunications and data processing between 1945 and 1960 (particularly miniaturized computers, increased computer calculating power and time-sharing) led, in the sixties, to the first efforts to use the computer for instructional purposes. Quite naturally, first thoughts were of a super

teaching machine which would greatly refine branching programming. CAI or Computer-Assisted Instruction, the generic term the Americans applied to the category, seemed to offer a solution for a good number of teaching problems. It made it possible not only to adopt the program* to the individual's learning rate, but also to grade difficulties, choose information in terms of the student's preceding results and so forth.

From the very beginning of developments in this field, two different types of use were generally distinguished:

- "CAI-Tutorial" using the computer to store information and supply it to the student on the basis of his answers to test questions;

- "CAI-Drill and Practice" using the computer as tireless tutor to ask the student questions, correcting his answers and pose new questions until the desired mastery is acquired.

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* The word "program " is used here in the same sense as in programmed instruction.

4.0 ...

Today the instructional uses of the computer are still generally interpreted as computer programmed instruction ("the computer teaches") or computer exercises. The preceding chapters showed that the computer has numerous applications which are sometimes completely different from those briefly described on these pages. They were all developed after CAI, however, and several are the result of new technical developments or the difficulties met in endeavoring to generalize CAI. This is the case, in particular, of the introduction of *computer-managed instruction* where the computer's role is reduced to making evaluations and suggestions. The use of computers is thus becoming less expensive and, from an instructional point of view, less arduous.

In our classification, CAI-type applications, come under the heading "the computer as a *teaching instrument*." There are three divisions within this application:

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* The invention of conversational languages (after 1965), for instance, greatly stimulated the development of *laboratory tool* type applications, at least in schools.

4.0 ...

- *drill and practice*
- *tutorial*
- *dialogue*

The Americans sometimes include *Simulation* and *Information retrieval* under the heading CAI, but, in our opinion, these applications belong in different categories.

4.1 *Drill and practice*

4.1.1 Presentation

In this case, the computer is used to give the student a large number of exercises to help him acquire a particular skill.

4.1.2 Examples

(i) At the Ontario Institute for Studies in Education (OISE), a system has been developed to enable a student who has not mastered certain specific mathematical skills to practice them (49). The computer evaluates the student using a technique explained earlier in this text*. The questions on the test are generated using a set procedure to which random values are given. A program consisting of a few instructions, can thus generate thousands of different examples. If the student has not mastered the skill, he is given a series of problems using the same procedure. This time, however, he is told whether his answer is correct. If it is not, the right

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* cf *individualized testing*, section 3.2.3

answer is supplied. This continues until the student's performance in the skill under consideration is judged satisfactory. Teaching through *drill and practice* consists in repetition giving the student automatic responses and thus greater ease in learning.

(ii) At the present time, the *drill and practice* programs developed by Stanford University under the direction of Patrick Suppes (67) are undoubtedly among the most popular in the United States. These programs include all the topics taught in elementary arithmetic and were already in wide use in 1967-68. Their popularity has not decreased.

Suppes' programs are extremely refined. In 1967, the entire arithmetic course was divided into "blocks". Each block covered a certain number of concepts and was subdivided into seven lessons. The first and last lessons consisted of a pretest and a posttest on the block. The five other lessons had five levels of varying difficulty. A lesson involved from 16 to 20 questions.

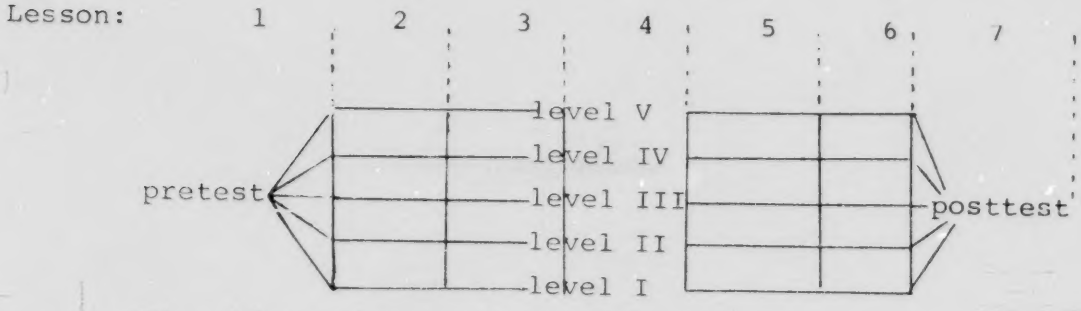

Fig. 14 *Diagram of a block*

The results obtained in the pretest determine the level of the exercises given the student during his first lesson (lesson 2). If the pupil gets less than 20% on the pretest, for instance, the system will give him level 1 exercises (easy) during the next session (see Fig. 15). If the pupil obtains between 60% and 79%, he begins at level 4.

When giving the exercises, the system compiles the results obtained by the pupil. These results are used to choose the next level in the pupil's progress.

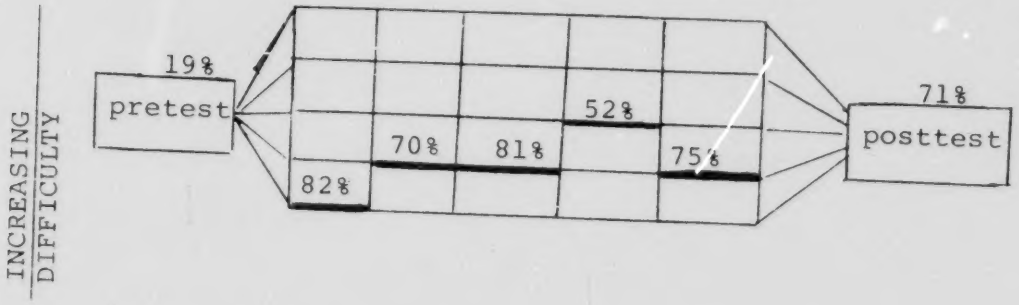

Fig. 15 *Typical progress within a block of drill and practice lessons. The heavy lines indicate the level of the lesson given the pupil.*

If the pupil obtains less than 60% in the first lesson, he is placed on a lower level in the next lesson. On the other hand, if he answers at least 80% of the questions correctly, he is guided towards a higher level in the next lesson. The same process is repeated until the end of the block.

The posttest is used to determine whether the pupil has attained the objectives set and to propose instruction to help him recoup.

Sessions at the terminal last about 10 minutes each day. The number of problems given depends on the speed with which the pupil answers and on the number of mistakes he makes. A lesson does not necessarily correspond to a session with the terminal. The computer notes how far the pupil has advanced at the end of the session and the next day the pupil need only register at the terminal to be given the subsequent exercises.

The computer, for example will print "2+2=...". The pupil types out his answer. If the answer is correct, the computer gives another problem such as "2-...=5". If the answer is incorrect a comment such as "No, try again" is given. The problem is posed once again. Upon receiving a second incorrect answer to the same question, the computer supplies the right answer and the question is asked again so that the student can give the correct answer himself. At the end of the session, the pupil is given his results.

4.1.3 Instructional aspects

Drill and practice is often used in arithmetic and for teaching vocabulary. It is also used for learning languages since this generally requires

repetition and practice.

The structure of *drill and practice* programs usually allows for comments on the pupil's errors. The comments are more or less specific* depending on the extent to which the answer is analyzed. The comment either acts as a stimulus or makes the pupil immediately aware of his error which he can then correct. It is well known how important immediately receiving one's results can be in the learning process.

4.1.4 Technical aspects

Programming for *drill and practice*-type applications is usually quite simple. Certain applications in arithmetic may require only a few instructions and yet permit the generation of an unlimited number of questions. Some computer instruction systems are equipped with special procedures for generating stereotyped exercise items.

Drill and practice requires the use of a conversational system. Typewriters and cathode ray tubes are the usual terminal used in these applications.

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* The pupil may simply be told his answer is incorrect; he may be told how serious his error is; or he may be taught in its entirety the rule he failed to apply.

4.1.5 Comparison with other types

Technically speaking question generation and answer correction as well as the organization of questions on the basis of pupil performance are techniques similar to those used for *individualized testing* and *test generation*: The difference is in the objective sought: testing is used to evaluate the attainment of objectives, *drill and practice* is used to reach the objectives.

Moreover, the comments given after students'answers are essential for *drill and practice* applications. But the computer doesn't have to comment students'answers while testing him.

The repetitive aspect of *drill and practice* must also be stressed. In fact, *test generation* system can be used to produce exercise items as well as test questions, but these are usually limited in number. When using *drill and practice* applications, the same type of question is asked until the desired performance is achieved.

4.1.6 Experiment results

Drill and practice is used in traditional lecture courses. It provides practice in newly-taught concepts and is often used to help slower students catch up.

The experiments performed (Reports 10 to 13) all dealt with elementary reading and arithmetic. It should be noted that some of the results obtained were rather spectacular either in the quantity learned or the speed with which subject matter was mastered.

4.2 Tutorial.

4.2.1 Presentation.

By tutorial*, we refer to the applications where the computer performs all the teaching actions normally performed by the teacher, in a continual interaction with the student. The computer transmits informations, controls the student progress through a course, and tests him in order to know if he attained his objectives.

This type of instruction was one of the earliest applications to be tried. This is quite understandable if we consider that in spite of the application's complexity, programmed learning had already reached an advanced stage of development and popularity when the first computerized instruction systems were perfected. It was natural to consider computer instruction as an extension of this technique and to use the computer first as a super teaching machine.

4.2.2 Instructional aspects.

The purpose of tutorial instruction is to make student learning quicker and easier by individualizing the teaching process.

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* This type of use is known by a considerable number of different terms: CAI, CAI-Tutorial, Computer Based Instruction (CBI), Automated Teaching, Computer Assisted Learning (CAL), and so forth.

Such individualization may take two aspects:

a) Individualization of the rate of progress within a course; this type of individualization is extrinsic to the teaching program and depends mainly on the rate at which a particular student approaches his material, on his choice of schedule, on the availability of material, and so forth.

b) Individualization of the instruction itself; this type of individualization is obtained by using course development methods designed for programmed instruction. Basically:

(i) The overall concepts are broken down into their smallest units.

(ii) These units are restructured as to recompose the initial concepts.

(iii) During the course, information is presented alternately with tests, the results of which determine the subsequent material. Generally, a typical and necessarily simplified tutorial interaction between computer and student includes the following:

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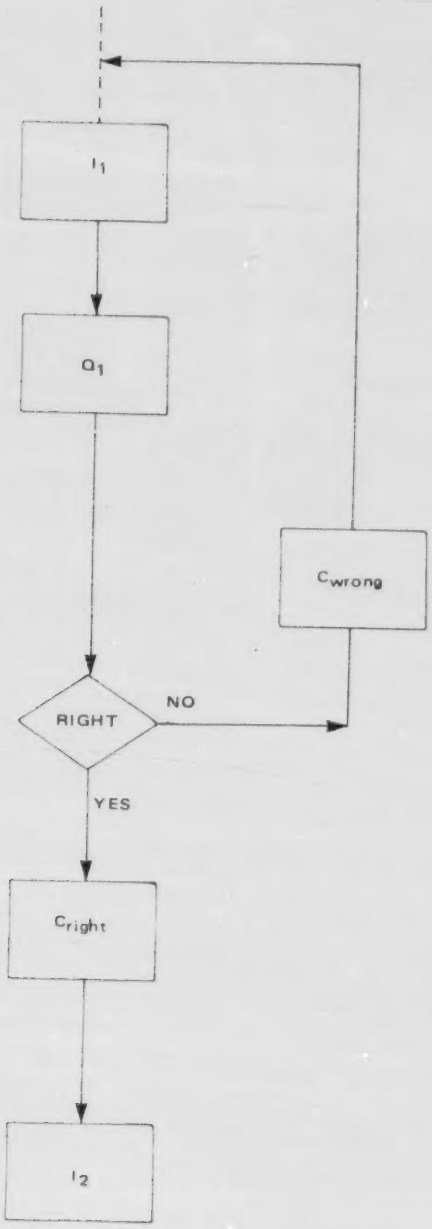
* This is the truly educational aspect of individualization; the other is more technical.



- information given to the student (I_1 and I_2);
- question testing comprehension of information (Q);
- analysis of the answer;
- comment adapted to the answer (C_{right} or C_{wrong}).

The process can be carried to extremes. Test results can have a bearing on several aspects of the presentation of material.

- the quantity of information presented at one time (scope),
- the quality of this information (difficulty),
- the method of presentation, itself depending on the medium and the strategy used,
- the interval between the tests,
- and so forth.

In fact, quite a number of variables are possible. This is why *tutorial* systems designed to take all the variables into consideration are still in the experimental stage today. The systems used are much simpler and resemble the general pattern given above. Some *tutorial* courses called , "page turners", are sometimes so simple as to be thoroughly annoying.

It may be seen that from the instructional viewpoint, *tutorial instruction* requires more than just a definition of objectives and the development of a testing instrument. It requires detailed study of the structure of the subject matter, decisions on the educational strategies to be em-

ployed, choice of a typical course orientation, experimentation with the details of course sequence, and so forth. In fact, planning a computer course is comparable in terms of the time and effort involved, to the preparation of an educational film script. It differs in the pupil-machine interaction, and an appreciable amount of additional time is required if a certain perfection is desired in this field.

Finally it should be stressed that the *tutorial* use of the computer facilitates validation and correction of courses. In fact, the computer, as well as instructing the student, can store (on file) a great deal of information concerning his progress, his test results, including details of his answers to the system's questions. The course writers have access to this information which, once analyzed, can be used to correct and improve the course.

4.2.3 Technical aspects:

Computerized *tutorial instruction* requires a conversational system since adapting the information to the student makes real-time interaction necessary.

The question of choice of equipment, languages and terminals is all the more complex since the number of systems offered is considerable (without counting the possible alternatives of permutation of equipment). In a few lines, here are the possible options and the questions generally discussed in the specialized articles.

(a) Computer.

One of the main questions asked is whether to choose a large or a small computer.

(b) Language or software.

There are a great many languages available. The main questions discussed concerning software are:

- languages for general use vs specialized languages for education;
- standardization of languages vs multiplicity of specialized languages;
- compatibility of software.

(c) Terminals.

At the present time typewriter-like (TWX, 2741) and cathode screens are the most widely used terminals. A new type, the plasma display panel, developed at the University of Illinois, could revolutionize the field. It is, in fact, very efficient and should cost less than the cathode ray tube presently available.

4.2.3 ...

For certain *tutorial* applications, small printers are also used; when the lesson is given on the cathode screen, they allow certain texts which the student wants to keep to be printed quickly.

4.2.4 Experiment results.

The experiment results are more numerous in *tutorial instruction* than in any other application. This is a good illustration of the versatility of this computer application, as regards both academic levels and subjects taught. Applications are mainly in the science field. Generally speaking, the experiments presented in Reports No. 14 to 27 covered short courses.

On the whole, experiments on *tutorial* use of the computer tend to show that:

- it offers instruction at least as effective as lecture courses (in class) from the viewpoint of the academic results of a group of pupils;

- it makes it possible to shorten learning time by 20 to 25 percent;

- it allows the most gifted child to deal with certain notions more quickly and the weakest pupil to take more time. The slowest pupil will take up to four times as long as the quickest pupil (observed difference).

4.3 *Dialogue.*

4.3.1 Presentation.

This type of computer instruction involves student control of course progress and information sequence through the possibility of natural language *dialogue* with the machine.

This use is also called "Inquiry" or "Learner-controlled".

Applications of this type are mostly in the experimental stage.

4.3.2 Example One.

At the Laboratoire de Pédagogie Informatique, the student taking the introductory courses to data processing and electrotechnics*, could ask questions in ordinary French if he did not understand a term, explanation or example. He

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* The introductory course to data processing lasted about 15 hours on the Laboratoire's 1500 system. The course in electrotechnics lasted about three hours.

could ask his questions at any time in the course and any way he liked, within the following limitations:

(a) his query had to deal with:

(i) a request for a definition (eg. "What is...", "define...", "What does... mean", and the like.),

(ii) a question on operation (eg. "How does... work", and so forth.),

(iii) a question about use (eg. "What is... used for", "What is the use of...", and the like.)

(b) the query had to deal with part of the course.

The student who wanted to make a query had to type a question mark (?) when he had control*. The program then sent the message: "Ask your question". The student typed his question which was analyzed by a program called the

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* It is said that the student has "control" when the system expects some kind of response from him: answer to a question, request to continue the course, and so forth.

analyzer*. First the program noted the type of question (definition, operation, use). Then, on the basis of the keywords, it determined the subject dealt with by the question. If an answer had been provided for the question the program gave it to the student. If not, the student was asked to rephrase his question. If the second attempt was fruitless, he was informed that it was impossible to answer his question at that moment.

All the questions asked by students were kept on file. This file also recorded the point in the course where a student had asked a question, and the address of the information he had received in reply. When there was no answer, a special signal was recorded. At regular intervals, these questions were printed on paper and it was possible to check whether the answers received by the students actually corresponded to the questions asked. If not, or if no answer had been given, the program could be modified to provide for new cases.

We have mentioned that the student could ask questions *during* the course. In this type of use (dialogue within a

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* For further detail on question analysis, the reader is referred to the Laboratoire reports (52,53).

tutorial course) with the analyzer which we had perfected, the students received answers to about 25 percent of their questions. However, this low rate of reply was not due to weaknesses in programming but rather to the use made of dialogue. In a special experiment conducted in the Laboratoire in February-March 1971, the response rate was about 75 percent. In that instance, the students were involved taking a course in Boolean algebra simply by asking questions*. Any information which reached them was elicited by a particular question. The experiment did not aim to measure the effectiveness of such a teaching method, but rather to assess its technical possibilities. The fact that the questions were answered about 75 percent of the time shows that if the machine is adequately programmed, two-way dialogue is possible.

4.3.3 Instructional aspects.

Instructional use of the computer is often criticized for being deterministic in method. The student exercises control over neither the information received, nor the manner of presentation. Even in the most highly developed systems,

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* There is no report available on this experiment. The Boolean algebra course was part of the introduction to data processing.

the individual taught is reduced to a typical pattern." The information goes from the machine to the student without him being able to control it other than indirectly, through his general performance or his answers to questions prepared in advance. *Tutorial instruction*, like programmed instruction is diametrically opposite to non-directive teaching.

The possibility of dialogue within a course, or dialogue-based instruction, allows self-determination in the student's learning. Attaining instructional objectives can be individualized, both in learning rate and time-table flexibility and in the way in which the objectives are mastered. This self-determination and freedom given the student is sometimes desirable, but is also sometimes necessary, as in the following example.

4.3.4 Example Two.

At Erindale College in Toronto, a team of educators studied the problems of teaching symbolic logic (71). According to them, these problems were as follows.

- The subject has always been difficult to teach.

- Above all, learning symbolic logic requires a great deal of practice directed by a person familiar with the subject. In fact, this learning requires a tutor.

- Although this difficulty may exist in teaching many other subjects it is almost impossible to learn symbolic logic, otherwise.

The program which was developed to enable the student to practise proving theorems actually *simulates* a tutor who follows the student's activity step by step. However, the tutor does not suggest or demand anything from the student; he converses with him. The interaction proceeds in the following way.

The language used is the language of symbolic logic itself, and this simplifies interpretation of the student's messages. When he questions the computer, he does so by formulating a theorem. He may ask the computer, (1) to check the proof he has already worked out, (2) to help him prove the theorem he is interested in.

The student who has a question to ask (a theorem to prove) goes to the terminal and identifies himself. He then types out the theorem and the proof he has prepared (if he cannot do it all, he writes out what he can). After each statement*, the computer checks whether it is valid (this is

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* A statement consists of a formula and a justification and corresponds to a line of type at the terminal.

4.3.4 ...

done by a program called "Theorem Prover"). If the statement is valid, the program lets the student continue his proof. If, however, the statement contains an error, the computer attempts to have the student find the weak point by asking him questions (this program is called a "Question Asker"). At any time the student may ask the computer a question about the statement he is unsure of or wishes to develop further. He has merely to propose this statement as a theorem.

It is easy to see that a genuine dialogue is involved in this case and that it is controlled by the student since he is defining the problems he wants to solve. Obviously, the domain of conversation is limited (proving theorems in symbolic logic), and the language is governed by rules which are far fewer and better defined than are those of natural language.

4.3.5 Technical aspects.

From the technical point of view, *dialogue* requires a conversational system. The terminal where the student will be working must of necessity have a keyboard to allow him to type his interventions. In the first example we gave, the Laboratoire de Pédagogie Informatique used the 1500 system and the "Coursewriter II" programming language. In the second example, an IBM 2741 teletype was used as the terminal and APL* as the programming language.

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* APL/CAT to be more precise. A programming Language/ Computer Assisted Teaching.

In a *dialogue* application, very special attention must be paid to structuring the information, programming the analyzers, and updating the system. From one system to another the techniques of sentence analysis may differ widely; the common denominator of all these systems, however, is the great length of time required for programming*

In the second example, and in cases where questions are asked with the help of a well defined vocabulary** , the question or answer is fairly easily analyzed. Moreover, since the information given is restricted to the field in which the conversation has been engaged, this information forms a whole and can be delimited.

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* We are including in the expression *programming* writing the appropriate software, designing the *logical analysis system* and programming it in a given language.

** In 4.3.6, cases will be discussed where there is the possibility of a rudimentary dialogue. A student may ask for specific information by using a prescribed code. In this case the application actually involves *information bank* management.

4.3.5 ...

On the other hand, in the more usual case where a dialogue in natural language is desired, the complexity and extent of the vocabulary and the semantic value of the word groups vastly increases the difficulty of the problem.

Two other problems arise along with the desire to dialogue with the computer, first, the storage space occupied by the analysis programs and dictionaries required for sentence recognition, and second, the analysis time involved. For effective dialogue the student must receive the answer to his question in no more than ten seconds, preferably in far less.

4.3.6 Comparison with other types.

In certain respects, the use of the computer in *dialogue* is not unlike its use as an *automaton*. In fact in the second case there actually is dialogue between the user and the system he is programming. However, such a dialogue is limited to a certain number of restricted known *activities* which the computer can perform. The vocabulary is limited and often quite different from natural language. The conversation takes place in the computer's language.

4.3.6 ...

Used as an automaton, the computer is not used for the actual instruction; it is simply a tool which can assist in the learning process. However, in *dialogue* systems the information given during the dialogue is directly involved in the learning process.

Computer *dialogue* is also related to the *information bank* type of use. In fact, the student or teacher consulting a data bank carries on a sort of conversation with the computer, especially when the consultation is in real time. The language used in this case usually consists of a series of codes which correspond with the logical organization of the data. The information bank management programs are much simpler than the question *analyzers* used for dialogue. The main difference between the two types of application (which can be almost identical* at times) is that in the case of *dialogue*, the information is structured in accordance with the instruction involved. Also, the information does not consist merely of objective definitions, or data with no reference to context, but is oriented so as to

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* The reader is referred to Maurice Peuchot's article on the "Diffusion automatique de l'information" for the present state of research in this field. (54).

encourage learning*.

4.3.7. Experiment results

Experiments on the use of the computer in *dialogue* are still in the research stage and tend to demonstrate technical possibilities rather than measure the actual effectiveness in teaching.

Research is mainly on the syntactical and semantic analysis of natural language sentences, and semantic analysis is by far the more difficult. Most of the time this research extends beyond the scope of instructional research. It frequently involves linguistic and semantic problems.

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* In the final analysis, if the student could use natural language to obtain access to an *information bank* when striving to reach his learning objectives, this use could be classified as a type of *dialogue instruction*.

4.4 *Teaching instrument* - Conclusions.

The use of the computer as a *teaching instrument* is the best known and most widespread application today. It has also been responsible for the greatest amount of formal research on its effectiveness and its possible fields of application.

Particularly when used in *tutorial* applications, with a terminal, the computer can transmit knowledge in the same way as other audio-visual media. In this respect certain techniques for dividing and presenting subject matter, selecting support material adapted to the information to be transmitted, and more generally, techniques for preparing instructional material are common to both areas. In this form, instructional use of the computer is better known to most *education technicians* than might be thought, considering its apparent novelty and complexity.

The fairly elaborate research arising from the use of the computer as a *teaching instrument* (especially for *tutorial* and *drill and practice* applications) seems to suggest its possible advantages, at least in the fields and for the student groups where its use has proven most worth while.

Dialogue is considered by some (6) as the application of the future. However, many instructional and technical restrictions must be overcome before such an application can become general.

4.5 Experiment reports

REPORT NO. 10

INSTITUTION CONCERNED : Computer Curriculum Corporation (C.C.C.)

USE : Drill and practice

LEVEL : Elementary

SUBJECT : Vocabulary

REFERENCE : (26)

COMMENTS :

The experiment involved 162 pupils from a slightly below-average socio-economic class.

Teletype terminals, model 33, and a Honeywell 1648 computer were used.

In the course of the year each pupil had 150 ten-minute sessions with the terminal.

Exercises were of the type:
An unkind person is ..... kind.
very not too
The pupil answered by typing out one of the three possibilities given.

The exercises were in groups of five; to change groups, 4 or 5 correct answers were required. When the pupil made only one error (4/5), the problem question could be included in the next group.

At any time the instructor could obtain a report on the work of a group of pupils doing computer exercises.

RESULTS :

The percentage of correct answers during the 1970-71 school year was:

Grade 3	:	.909
Grade 4	:	.898
Grade 5	:	.901
Grade 6	:	.925
All grades	:	.908

The authors also noted the number of groups of 5 exercises completed per minute:

Grade 3	:	.708
Grade 4	:	.608
Grade 5	:	.532
Grade 6	:	.534
All grades	:	.588

The drop observed (.70 to .53) may be explained by the increased number of texts to be read or typed in grades 5 and 6.

In general, the authors found that on the average pupils learn twice as many new words in computer sessions than in sessions with a teacher.

REPORT NO. 11

INSTITUTION CONCERNED : Stanford University

USE : *Drill and practice*

LEVEL : Elementary

SUBJECT : Arithmetic

REFERENCE : (37)

COMMENTS :

The experiment involved about 6,000 pupils and 192 terminals in 15 elementary schools in Manhattan, the Bronx and Brooklyn.

One group of pupils (group A) received traditional instruction followed by *drill and practice* at a terminal.

Another group (group B) received only the traditional instruction.

RESULTS :

The following tables set forth observations on the amount of material mastered by the pupils after five months, on the one hand, and on the other, an estimate for a nine-month period.

GROUP	OBSERVATIONS AFTER 5 MONTHS
A	8.4
B	5.0
Difference	3.4

GROUP	ESTIMATE FOR A NINE-MONTH PERIOD		
	ABOVE-AVERAGE CASES	AVERAGE CASES	BELOW-AVERAGE CASES
A	19.8	15.1	8.4
B	10.0	9.0	8.0
Difference	9.8	6.1	0.4

As shown in the second table, the computer sessions would result, over a nine-month period, in a gain of six months (in the average case) over traditional instruction methods.

P. Suppes notes moreover, that the weaker pupils profit most from computer instruction.

REPORT NO. 12

INSTITUTION CONCERNED : Public School of McComb, Mississippi and Franklin County, Mississippi

USE : *Drill and practice*

LEVEL : Elementary

SUBJECT : Arithmetic

REFERENCE : (24)

COMMENTS :

The experiment involved 200 grade 6 pupils. An experimental group of 100 pupils had five minutes *drill and practice* with the computer every day in addition to traditional instruction.

RESULTS :

The results of the posttest showed a difference between the two groups at a .01 level of significance. In the authors' opinion, the computer proved to be an effective tool for complementing traditional instruction with *drill and practice*.

REPORT NO. 13

INSTITUTION CONCERNED : Stanford University

USE : *Drill and practice*

LEVEL : Grade 1

SUBJECT : Reading and arithmetic

REFERENCE : (60)

COMMENTS :

The authors were trying to evaluate the influence of computer courses on the behavior of pupils in class. Forty-five pupils spent 35 minutes a day at a terminal between the fall of 1966 and the spring of 1967 (half for reading and half for arithmetic).

A control group of twenty-seven pupils were taught reading and arithmetic by a teacher.

RESULTS :

There was no difference between the two groups' attitudes in class. Results obtained in reading (and less markedly in arithmetic), however,

confirm the belief that computer instruction reduces the relation between performance and attitude in class.

REPORT NO 14

INSTITUTION CONCERNED : Laboratoire de Pédagogie Informatique, Québec Department of Education.

USE : *Tutorial*

LEVEL : Secondary and College

SUBJECTS : Physics, Data processing, Mathematics.

REFERENCES : (8,28)

COMMENTS :

The Penn-State attitude test was administered to five groups of pupils who had taken various courses at the computer terminal between 1970 and 1972.

GROUP	COURSE	NUMBER	AGE	SEX	DATE
I	Thevenin Theorem	22	18-19	M	Fall 1970
II	Intro. to data processing	28	16-17	M	Fall 1970
III	Intro. to data processing	35	17-18	23M 12F	Fall 1971
IV	Intro. to data processing	23	18-19	F	Spring 1972
V	Vector calculus	24	20	F	Fall 1970

Moreover, in a sixth group (VI) 35 Secondary V students took the introductory course in data processing in the fall of 1971. They then took the PERPE-LPI test for the purpose of discovering the priorities in improving the course. The PERPE-LPI test is based on the discrepancy between the actual situation and the desired situation, and measures various aspects of the students' dissatisfaction.

RESULTS:

With group VI the following percentages of dissatisfaction were noted:

Answer analysis	89%
Loops in the progress of the course	89%
Possibility of additional information	83%

Moreover 89% of the students contradicted one another as to the difficulty of the exercises.

The table on the following pages shows the statements selected from the Penn-State test, their numbers and the conclusions which can be drawn from the opinions expressed by the pupils of groups I to V. D indicates disagreement, C contradiction and A, agreement.

STATEMENT NUMBER	STATEMENT	CONCLUSIONS
8	Computer-Assisted Instruction makes the learning too mechanical	D
12	Computer Assisted Instruction is an inefficient use of the student's time	D
14	I felt frustrated by the Computer-Assisted Instruction situation	D
16	Even otherwise interesting material would be boring when presented by Computer-Assisted Instruction.	D
18	In view of the amount I learned, I would say Computer-Assisted Instruction is superior to traditional instruction.	C
19	With a course such as I took by Computer-Assisted Instruction, I would prefer Computer-Assisted Instruction to traditional instruction.	C
20	I am not in favor of Computer-Assisted Instruction because it is just another step toward depersonalized instruction.	C
36	Otherwise boring material would be interesting when presented by Computer-Assisted Instruction.	A
72	Computer-Assisted Instruction made it possible for me to learn quickly.	A

Possible answers ranged from vigourous disagreement to hearty agreement and were scaled from 1 to 5.

It is interesting to note vigorous disagreement with statements number 12 and 14 and agreement with number 36.

These results show that although improvements are required in the courses, generally speaking the students are in favor of computer-assisted instruction.

REPORT NO 15

INSTITUTION CONCERNED : University of Florida

USE : *Tutorial.*

SUBJECT : Mathematics: significant figures.

REFERENCES : (18).

COMMENTS :

The writers compare a programmed course with the same course given by computer and supplemented with additional information on incorrectly answered points. The terminals were cathode ray screens.

64 students took the 52 course units.

Results were based on a posttest, a retention test and the mistakes made during the course.

RESULTS :

The students using the programmed texts were significantly more successful than those working with the computer.

The writers attribute this difference to the pupils of low ability who worked with the cathode ray screen and conclude that pupils in this category require paper as an aid to memory.

LPI Report, 1973, vol. I

REPORT NO 16

INSTITUTION CONCERNED : Montgomery County Public Schools.

USE : Material.

LEVEL : Secondary.

SUBJECT : Mathematics.

REFERENCE : (56).

COMMENTS :

This involved a survey in which students were asked for an appreciation on:

I- themselves as students,
II- the school as a whole,
III- mathematics,
IV- computer-based instruction.

The survey covered 350 students in 16 classes; eight of these classes had received additional mathematics classes with the computer.

The students were then asked to arrange the following computer roles in order of importance:

.../

A - testing,

B - study of new material,

C - review,

D - games (eg. chess),

E - practice in a difficult subject,

F - calculations (eg. square roots),

G - program writing.

RESULTS :

The students' classification produced the following results as to the relative importance of the computer's roles:

ROLE	AVERAGE RANK	
B- study	2.27	the most important
E- practice	2.77	
C- review	2.87	
F- calculations	4.09	
A- testing	4.82	
G- programs	5.19	
D- games	6.03	the least important

Moreover students' appreciation on the four points mentioned (I, II, III, IV) resulted in the percentages on the next page.

.../

	REACTION OF ALL THE STUDENTS		
	favorable	neutral	unfavorable
I	53.1%	28.8%	18.1%
II	60.7%	18.8%	20.5%
III	58.9%	19.9%	21.2%
IV	57.2%	29.5%	13.3%

The pupils' favorable attitude toward computer-based instruction represents mainly the appreciation of those who actually used it (61.4% vs 53.0%). Also, the favorable attitude towards mathematics stems from the appreciations given by those pupils who had taken additional instruction with the computer (60.0% vs 57.8%).

REPORT NO 17

INSTITUTION CONCERNED : University of Saskatchewan.

USE : *Tutorial.*

LEVEL : University.

SUBJECT : FORTRAN (Introduction to Programming).

REFERENCE : (12).

COMMENTS :

The experiments involved 76 students divided into three groups. Each of the groups took a course in Fortran:

- Group I had a teacher,
- Group II received programmed instruction,
- Group III received computer-assisted instruction.

On the Regina campus there were two IBM 2741 terminals available, connected with an IBM 360/67 computer in Edmonton.

RESULTS :

The three groups took three Fortran tests, did four problems and wrote a final examination.

Students performances were considered equivalent in all three types of instruction.

It was observed that the students were very favorably disposed toward the computer.

As far as learning time was concerned, the students noted that it took about 750 minutes to take the course by programmed instruction, 300 to take the course in class, and an average of 225 minutes to take the course with the computer.

REPORT NO 18

INSTITUTION CONCERNED : Mercy Hospital School of Nursing (PLATO III)

USE : Tutorial

SUBJECT : Nursing

REFERENCE : (9).

COMMENTS :

A group of 100 students took 22 lessons at a terminal. A control group received the same course in formal lectures.

There were 70 terminals connected with a CDC 1604 computer; twenty of these terminals could be used at the same time.

RESULTS :

There was no significant difference between the marks of the two groups. The experimental group spent between 28 and 40 hours taking the course at the terminal. The control group spent about 84 hours in class. A survey indicated that 50 percent of the experimental group preferred the computer to other instructional media. Four students out of five stated that the equipment did not interfere with concentration.

REPORT NO 19

INSTITUTION CONCERNED : U.S. Army Signal Center and School
Fort Monmouth.

USE : Tutorial

LEVEL : Professional.

SUBJECT : Electronics.

REFERENCE : (2).

COMMENTS :

The purpose was to compare traditional instruction with computer-assisted instruction. Comparisons were carried out with two groups of 155 students in phase one and two groups of 121 in phase two.

RESULTS :

For phase 1, there was a 5 percent level of significance in the difference between the marks obtained; the difference was at the one percent level of significance for the number of failures. A more searching study showed that these differences were due to the weakest students. Accordingly computer-assisted instruction increases in effectiveness as the ability of the pupils decreases.

In phase 2, there were no failures after the

.../

computer-assisted instruction while there were seven after traditional instruction.

Moreover, the students gained about 25 percent in time using the computer:

30 hours instead of 42 in phase 1

23 hours instead of 30 in phase 2.

Finally, the attitude test showed that the students preferred computer-assisted instruction.

INSTRUCTION	BY COMPUTER	TRADITIONAL
	PHASE I	
MARKS	104	101
FAILURES	26	33
TIME	29.55	42.00
	PHASE 2	
MARKS	114	111
FAILURES	0	7
TIME	23.02	30.00

REPORT NO 20

INSTITUTION CONCERNED : University of Pennsylvania.

USE : *Tutorial*

LEVEL : The students were elementary school teachers.

SUBJECT : Mathematics.

REFERENCE : (31).

COMMENTS :

The available data involved 134 students.

The students had about eight sessions at the terminal (8.18) over a twenty-two day period (21.85), that is, an average of approximately nineteen hours at the terminal (19.24).

RESULTS :

The students took a pretest and a posttest of 80 multiple-choice questions. They also took a pretest and a posttest on their attitude toward mathematics. Finally they took an attitude posttest on the instruction method.

The following figures were obtained:

	PRETEST	POSTTEST
RESULTS OBTAINED	51.40	69.65
ATTITUDE TOWARDS MATHEMATICS	92.14	93.01

The attitude toward the computer proved to be highly favorable.

It was also observed that the slowest students took four times as long as the fastest.

REPORT NO 21

INSTITUTION CONCERNED : University of Florida

USE : Tutorial.

LEVEL : Secondary.

SUBJECT : Chemistry.

REFERENCE : (66).

COMMENTS :

The purpose of the experiment was to study the short term effectiveness of tutorial computer instruction for certain chapters in high school chemistry. The students took a posttest after the course and another sixty days later.

RESULTS :

On both tests the control group obtained marks that were 20 percent higher than those of the experimental group. However the experimental group took only half as long.

Generally speaking there was a favorable interest in the computer.

REPORT NO 22

INSTITUTION CONCERNED : Education Development Dept.
IBM UK Ltd.

USE : *Tutorial*

LEVEL : University

SUBJECT : Pittsburgh Interpretative Language (PIL programming language).

REFERENCE : (20).

COMMENTS :

Twenty first-year students in mathematics and data processing were divided into three groups.

Group A :

Seven students took the course and exercises in class.

Group B :

Six students took the course by computer and the exercises in class.

Group C :

Seven students took the course and the exercises at the terminal.

.../

RESULTS :

It was found that the good students were just as successful with any instructional method. The least gifted pupils did better with the computer because of individualization.

Students whose results were above average on the pretest and below on the posttest found waiting at the terminal objectionable; they felt they were too slow at typing and that computerized instruction was too impersonal.

REPORT NO 23

INSTITUTION CONCERNED : Montgomery County Public Schools.

USE :

LEVEL : High School.

SUBJECT : Algebra.

REFERENCE : (57).

COMMENTS :

The experiments involved 89 students; 44 in the experimental group and 45 in the control group. Both groups received traditional instruction.

In the experimental group, the students who required additional information got it from the computer.

RESULTS :

As expected, there was a significant increase for both groups in the marks obtained on the post-test as opposed to the pretest. However, as may be seen in the table on the next page, the experimental group's marks increased the most; the difference (2.63) was at a .05 level of significance; these results are based on the 22 lowest marks of each group on the pretest.

		Experimental Group	Control Group	Difference
PRETEST	average	14.73	14.82	0.09
	standard deviation	2.99	2.08	////
POSTTEST	average	21.50	18.95	2.55
	standard deviation	4.24	4.07	////
GAIN	average	6.77	4.14	2.63
	standard deviation	3.15	4.14	////

REPORT NO 24

INSTITUTION CONCERNED : LPI, Québec Department of Education.

USE : Tutorial.

LEVEL : Teacher's College

SUBJECT : Mathematics: vector calculus.

REFERENCES : (68).

COMMENTS :

Twenty-four students were divided into three random groups. The three groups took the course at a terminal.

- Group A took the course on a cathode ray screen with a slide projector and a recorded text;
- Group B took the course at the cathode ray screen with a recorded text; photos were in an accompanying book;
- Group C took the course at a cathode ray screen; the text of the recordings and the photos were in an accompanying book.

.../

RESULTS :

The following table shows averages and standard deviations for the three groups on the pretest and posttest.

GROUP	PRETEST		POSTTEST	
	Average	Standard Deviation	Average	Standard Deviation
A	26.88	8.99	76.88	5.56
B	27.50	7.07	73.75	4.84
C	25.63	11.84	71.88	13.91

The table below gives the average and standard deviation in time (minutes) taken to cover the course:

GROUP	AVERAGE	STANDARD DEVIATION
A	140.75	23.80
B	144.00	33.39
C	173.50	28.66

The overall average was 152.75 minutes. In groups A and B, 12 students out of 16 took less than 152.75 minutes and in Group C, 6 out of 8 took more than 152.75 minutes.

The quickest student took 103 minutes and the slowest 213 minutes.

From the standpoint of time, there was no significant difference between groups A and B; on the other hand the difference between group (A+B) and group C was at the .01 level of significance.

The results on the Penn-State attitude test show that 93 percent of the students were satisfied with the media used.

Generally speaking, the following attitudes towards computer-assisted instruction were observed.

15 favorable,

3 neutral,

6 unfavorable.

REPORT NO 25

INSTITUTION CONCERNED : Naval Personnel and Training Research Laboratory.

USE : Tutorial.

LEVEL : Professional.

SUBJECT : Physics: alternating current.

REFERENCE : (27).

COMMENTS :

The report is dated May 1970. Fifty-one students were randomly selected from 251 to form the experimental group.

The remaining 200 students formed the control group.

At the end of the experiment, the two groups took the regular school examination and an additional test on objectives not measured by the examination.

RESULTS :

Experimental group students had greater success than the control group in both the examination and the test.

Moreover, the experimental group took from 33 percent to 44 percent less time than the control group.

REPORT NO 26

INSTITUTION CONCERNED : Naval Personnel and Training Research Laboratory.

USE : Tutorial.

LEVEL : Professional.

SUBJECT : Physics: inductance

REFERENCE : (35).

COMMENTS :

The report is dated March 1971. Fifty students were randomly selected from 230 to form the experimental group. The other 180 formed the control group. The experiment was similar to No. 25.

RESULTS :

On the additional test the experimental group did much better than the control group. On the examination there was no difference. When the marks were combined, the experimental group was about 10 percent superior to the control group; moreover with an average of 8.75 hours, it reduced by 48 percent the time required by the control group.

REPORT NO 27

INSTITUTION CONCERNED : LPI, Québec Department of Education.

USE : *Tutorial and Dialogue.*

LEVEL : College.

SUBJECT : Physics: Thevenin Theorem.

REFERENCES : (33).

COMMENTS :

The course was divided into 17 units. About forty additional units served to answer the students' questions.

Questions could be asked in everyday French.

The experimental group comprised 22 students and the control group 92.

RESULTS :

The average mark obtained on the posttest was 51.7% with the computer (experimental group) and 47.7% with traditional instruction (control group).

The average time taken to over the course was 2 hours 54 minutes.

The quickest student took one hour 54 minutes, the slowest 3 hours 43 minutes.

The traditional course took one hour 55 minutes.

The following opinions came to light on the Penn-State test.

10 highly favorable
19 favorable
12 uncertain
1 negative.

Concerning the opportunity offered students to ask questions, there were:

49 requests for definitions
63 requests for help.

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